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Operations and Maintenance Plan for the Rocky Flats Surface Water Control Project

U.S. Department of Energy

Office of Legacy Management

Work Performed Under DOE Contract No. DE–AM01–07LM00060
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Dams A-1, A-2, A-3, A-4, B-1, B-2, B-3, B-4, B-5, C-1, C-2, and the Present Landfill Dam

Associated Diversion Structures, Bypass Pipelines, Canals, and Functional Channels

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Acronyms and Abbreviations

CDPHE	Colorado Department of Public Health and Environment
cfs	cubic feet per second
COU	Central Operable Unit
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ERP	Emergency Response Plan
FC	functional channel
fps	feet per second
HEC-RAS	Hydrologic Engineering Center-River Analysis System
IC	institutional control
LM	Legacy Management
NPH	No Public Hazard
OU	operable unit
PLFTS	Present Landfill Treatment System
POU	Peripheral Operable Unit
PVC	polyvinyl chloride
RFLMA	*Rocky Flats Legacy Management Agreement*
RFSOG	*Rocky Flats Site Operations Guide*
SEO	State Engineer's Office
SID	South Interceptor Ditch
UDFCD	Urban Drainage and Flood Control District
USDCM	*Urban Storm Drainage Criteria Manual*
USFWS	U.S. Fish and Wildlife Service

Communications Directory

Title Department/Agency	Contact Name	Contact Numbers	Email and/or address
Dam Owner Representative U.S. Department of Energy	Scott Surovchak	(W) 720-377-9682 (M) 303-653-6750 (Fax) 720-377-3829	scott.surovchak@lm.doe.gov
Caretaker / Pond Operations Engineer Stoller Legacy Management	George Squibb	(W) 720-377-9675 (M) 303-994-0145 (H) 303-478-8568 (Fax) 720-377-3829	george.squibb@gjo.doe.gov
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City of Westminster	Public Works	(W) 303-430-2400	
Colorado Department of Public Health and Environment	Carl Spreng	(W) 303-692-3358 (Fax) 303-759-5355	carl.spreng@state.co.us
Office of State Engineer	Mike Hammer	(W) 970-352-8712 (Fax) 970-892-1816	mike.hammer@state.co.us
Jefferson County	Mark Gutke	(Fax) 303-271-4905	mgutke@co.jefferson.co.us
U.S. Environmental Protection Agency	Vera Moritz	(W) 303-312-6981 (Fax) 303-312-6067	moritz.vera@epa.gov
Colorado Division of Wildlife	Thomas Nesler	(W) 303-291-7461 (Fax) 303-291-7114	tom.nesler@state.co.us
Rocky Flats Stewardship Council	Rik Getty	(Fax) 303-412-1211	rgetty@rockyflatssc.org

Emergency Preparedness Plan

Although not required by the *Rules and Regulations for Dam Safety and Dam Construction* (State of Colorado 2007) based on dam classifications for the Rocky Flats Site dams, the site has prepared the *Emergency Response Plan for the Rocky Flats Site Dams* (DOE 2008a). This plan describes response actions required in the event of an actual or potential unplanned release or emergency discharge of water from detention ponds at the Rocky Flats Site, or the actual or potential failure of a dam. It defines action levels for categorizing conditions up to and including dam failure and addresses responses used in mitigating actual or potential dam failures and unplanned releases, including emergency spillway discharges.

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1.0 Introduction

The Rocky Flats Site (Rocky Flats) is under the jurisdiction of the U.S. Department of Energy (DOE) Office of Legacy Management (LM). Long-term surveillance and maintenance activities at Rocky Flats are conducted under the Legacy Management Support contract by S.M. Stoller Corp. (Stoller). Operation and management of the site surface water dams are performed as part of the surveillance and maintenance activities implemented at Rocky Flats, which include activities conducted pursuant to the Rocky Flats Legacy Management Agreement (RFLMA) (DOE 2007). RFLMA established the regulatory framework to implement the final response action selected and approved in the Rocky Flats Corrective Action Decision/Record of Decision under the Comprehensive Environmental Response, Compensation and Liability Act, the Resource Conservation and Recovery Act, and the Colorado Hazardous Waste Act to ensure the response action remains protective of human health and the environment.

This *Operations and Maintenance Plan for the Rocky Flats Surface Water Control Project* (O&M Plan) was prepared to establish in one primary document (with associated supporting documents) the complete, accurate, current, and structure-oriented operating instructions for each dam and reservoir and its related structures. The purpose of the O&M Plan is to ensure adherence to approved operating procedures over long periods of time and during changes in operating personnel. The instructions will also permit responsible persons who are knowledgeable in reservoir operation, but are unfamiliar with the conditions at a particular dam, to operate the dam and reservoir during emergency situations and at such times when the normal duties of the regular operator cannot be performed.

While the dams and reservoirs (also called "ponds") are not a component of the final response action, the following RFLMA requirements apply to some aspects of the instructions in this O&M Plan.

- Institutional controls (ICs) that prohibit certain activities without prior approval or that require activities to be conducted in accordance with approved procedures. The ICs are contained in RFLMA Attachment 2, Table 4, and include, among other things, prohibitions on excavations, certain uses of surface water and groundwater, and activities that may impair water monitoring components; and
- Protocol for pre-discharge sampling of Ponds A-4, B-5, and C-2 and notification of discharges.

This O&M Plan was produced primarily for the use of operating personnel located at or nearest to the dam and their immediate supervisors who are assigned the responsibility for the operation and maintenance of the dam. This O&M Plan contains, at a minimum, all information and instructions necessary for operating personnel to perform their duties. Operating procedures shall not deviate from those stated in this O&M Plan without appropriate authorization and shall be reviewed and updated periodically by qualified personnel.

This O&M Plan details the site water management practices, operations, maintenance, and monitoring for the 12 surface water retention ponds and other major stormwater management structures. The following details are provided:

- Infrastructure descriptions—Detailed descriptions of dams, ponds, spillways, outlet works, diversion structures, functional channels, and canals;
- Pond management practices—Overview of water management strategies under both normal and emergency[1] conditions for all site ponds;
- Operating instructions—Instructions for pond drawdown rates, drain bed valve operation, outlet works operation, and methods for evaluating and reporting unusual conditions;
- Maintenance and inspection instructions—Discussion of operating record generation and maintenance/inspection instructions for dams, ponds, spillways, outlet works, pipe crossings, diversion dams, functional channels, and canals; and
- Monitoring instructions—Detailed instructions for monitoring data collection associated with pond water levels, piezometer water levels, seepage, and dam structures (displacement, movement monuments, and inclinometers).

Supporting information is presented in a series of appendixes as follows:

- Appendix A—Dam Data;
- Appendix B—Operation Log;
- Appendix C—Monthly Observation Report;
- Appendix D—Piezometer and Pond Levels Field Sheet;
- Appendix E—Flume Ratings;
- Appendix F—Inspection and Maintenance Schedule;
- Appendix G—References;
- Appendix H—Capacity Charts and Graphs;
- Appendix I—Dam Locations and Access Roads;
- Appendix J—Permanent Instrumentation Data;
- Appendix K—Piezometer Summary Data;
- Appendix L—Example Data Reports; and
- Appendix M—Schematic for Current Flow and Water Transfer Network.

[1]Detailed emergency response procedures are contained in the *Emergency Response Plan for the Rocky Flats Site Dams* (ERP; DOE 2008a). Any references to emergency operations in this document are subject to modification by the ERP. In case of discrepancies between this document and the ERP, the ERP will take precedent.

2.0 General Information

2.1 Project Purpose

The Rocky Flats Surface Water Control Project consists of 12 earthfill dams and appurtenant spillways, 2 concrete and rockfill diversion dams, 2 concrete diversion structures with bypass pipelines, 5 engineered functional channels, and several canals/ditches (Table 2−1). The majority of the project features are located within the Central Operable Unit (COU)[1] (Figure 2−1 and Figure 2−2), and access is normally from roads from the west of the site as shown on the Dam Location and Access Roads map in Appendix I.

The general purpose of the project is to collect runoff originating west of the site and divert the flow around the COU and to collect runoff from the COU and retain it or safely route it through the site.

Table 2−1. Project Features and Functions

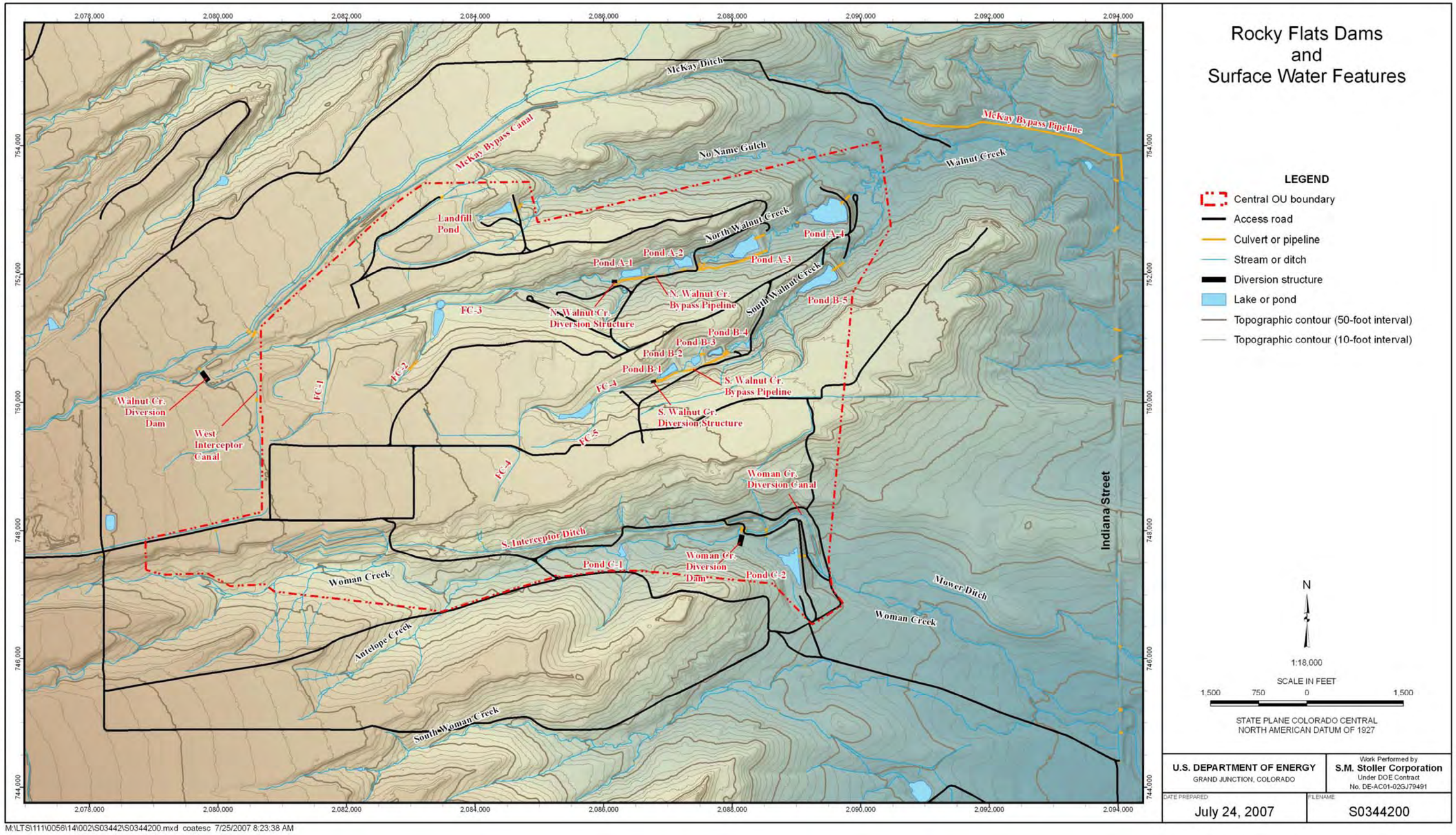
Project Feature	Function
Dam A-4	Stores or passes the 100-year Rocky Flats Plant (plant) runoff in North Walnut Creek and passes greater flows. During normal operation water is retained, sampled, and discharged when water quality standards are met.
Dam B-5	Stores or passes the 100-year plant runoff in South Walnut Creek and passes greater flows. During normal operation water is retained, sampled, and discharged when water quality standards are met.
Dam C-2	Stores or passes the 100-year plant runoff in Woman Creek area and passes greater flows. During normal operation water is retained, sampled, and discharged when water quality standards are met.
Present Landfill Dam	Stores or passes the 100-year event (runoff and seepage from the Present Landfill area).
Dam A-3	Routes North Walnut Creek flows into A-4 and provides additional storage capacity.
Dams A-1, A-2, B-1, B-2, and B-3	Provide a small amount of emergency capacity and provide wetlands habitat. No available data indicate that these dams were designed to store or pass any specific storm events.
Dams B-4 and C-1	Flow-through structures that provide some flow attenuation and settlement. No available data indicate that these dams were designed to store or pass any specific storm events.
North Walnut Creek Diversion Structure and Bypass Pipeline	Intercepts flow from North Walnut Creek and delivers water to any of the A-Series ponds.
South Walnut Creek Diversion Structure and Bypass Pipeline	Intercepts flow from South Walnut Creek and delivers water to either B-1 or B-4.
West Interceptor Canal	*Intercepts 100-year runoff from west of the COU and delivers water to Walnut Creek Diversion Dam.*
Walnut Creek Diversion Dam	*Diverts 100-year flow from Walnut Creek and the West Interceptor Canal through headworks into McKay Bypass Canal. Passes larger flows to North Walnut Creek and the A-Series Ponds.*

[1] The COU represents the DOE retained land and defines DOE's area of responsibility. Although several structures outside the COU are not maintained by DOE, they are discussed in this document due to their function as diversion structures and their importance to downstream DOE structures.

Table 2−1 (continued). Project Features and Functions

Project Feature	Function
McKay Bypass Canal	*Bypasses 100-year flow from Walnut Creek Diversion Dam around the A-Series ponds.*
McKay Bypass Pipeline (operated and maintained by the City of Broomfield)	*Intercepts flows in the McKay Bypass Canal and delivers water downstream of the Broomfield Diversion Structure.*
Woman Creek Diversion Dam	Diverts 100-year flow from Woman Creek through headworks into Woman Creek Bypass Canal. Passes larger flows to Pond C-2.
Woman Creek Diversion Canal	Bypasses 100-year flow from Woman Creek Diversion Dam around Pond C-2.
South Interceptor Ditch	Intercepts 100-year runoff from the southern portion of the COU and delivers water to Pond C-2.
Functional Channel (FC)-1	Routes runoff from the northwest corner of the COU to North Walnut Creek.
FC-2 and FC-3	Route runoff from the northern portion of the COU to North Walnut Creek.
FC-4 and FC-5	Route runoff from the central portion of the COU to South Walnut Creek.

Note: *Italicized* features are outside the COU and are not maintained or managed by DOE.



Rocky Flats Dams and Surface Water Features

LEGEND

- Central OU boundary
- Access road
- Culvert or pipeline
- Stream or ditch
- Diversion structure
- Lake or pond
- Topographic contour (50-foot interval)
- Topographic contour (10-foot interval)

N

1:18,000

SCALE IN FEET

1,500 750 0 1,500

STATE PLANE COLORADO CENTRAL
NORTH AMERICAN DATUM OF 1927

U.S. DEPARTMENT OF ENERGY GRAND JUNCTION, COLORADO	Work Performed by S.M. Stoller Corporation Under DOE Contract No. DE-AC01-02GJ79491
DATE PREPARED: July 24, 2007	FILENAME: S0344200

Figure 2−1. Rocky Flats Dams and Surface Water Features

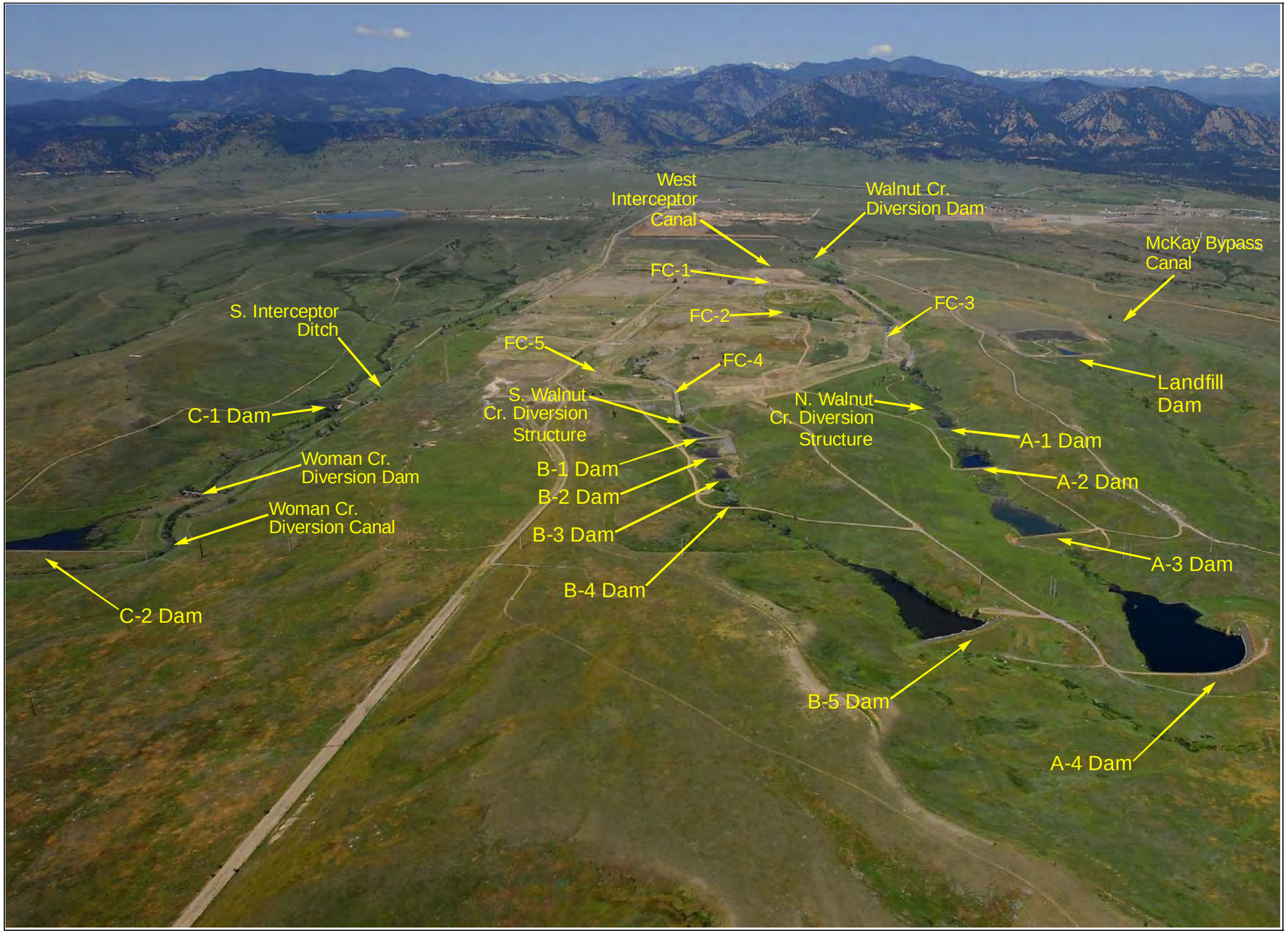


Figure 2−2. Aerial Image with Rocky Flats Dams and Surface Water Features

2.2 Assignment of Responsibility

DOE has a prime interest in the dam and reservoir area and a continuing responsibility for ascertaining that unauthorized encroachments do not occur, existing or potential conditions do not lead to public criticism or injury to the public, and nothing is done that conflicts with the primary purpose of the project.

Responsible site personnel are listed below:

- Dam owner representative—Scott Surovchak (DOE);
- Caretaker/pond operations project engineer—George Squibb (LM Stoller);
- Superintendent—Jeremiah McLaughlin (LM Stoller);
- Dam engineer—Mel Madril (LM Stoller); and
- Field technician—Andy Carpenter (LM Stoller).

The personnel listed above comprise monitoring, engineering, and supervisory individuals who respond to normal and emergency conditions affecting the project. The responsibilities include:

- Inspecting and monitoring the status of detention ponds and dams to identify conditions adversely affecting a dam;
- Coordinating periodic formal safety inspections;
- Coordinating periodic monument surveys;
- Performing periodic inclinometer readings;
- Performing periodic inspections of shorelines, riprap, embankments, spillways, outlet structures, trash racks, gates/valves, flumes, pipe crossings/headworks, channels, and rock grade controls;
- Ensuring availability of essential materials and, if needed, coordinating storage to ensure access in an emergency response;
- Performing monitoring, notification, and assistance in an EMERGENCY condition, on-scene assessment, emergency response actions, and issuance of personnel protective measures;
- Providing personnel to operate the equipment and/or open valves, as required;
- Ensuring resources are coordinated with emergency response personnel;
- Monitoring and sampling detention pond water on a routine basis;
- Performing routine pool elevation and piezometer monitoring;
- Performing pond water transfers and discharges;
- Providing pumps and associated materials as required for pond transfers and/or discharges; and
- Performing periodic maintenance for all items listed above.

The State of Colorado Department of Water Resources (State Engineer) has jurisdiction over the site dams. Site dams must be managed according to the *Rules and Regulations for Dam Safety*

and Dam Construction (State of Colorado 2007). Dams A-4, B-5, C-2, and the Present Landfill Dam are rated as "Low Hazard" by the State. Dams A-1, A-2, A-3, B-1, B-2, B-3, B-4, and C-1 are rated as "No Public Hazard (NPH)." State dam classifications range from "High Hazard" (highest concern, loss of human life expected if dam fails) to "No Public Hazard (NPH)" (lowest concern, no loss of human life expected if dam fails; damage limited to dam owner's property). Modification of a dam and related structures and appurtenances cannot be accomplished without the concurrence of the State Engineer.

The Inspection and Maintenance Schedule is provided in Appendix F.

2.3 Attendance, Communications, and Warning Systems

The primary communications system for site personnel is the commercial telephone system. The hydrometeorological data collection system (telemetry system) transmits pond data, including select pool elevations, discharge rates, inflow rates, and piezometer water levels to the Rocky Flats office at 11025 Dover Street, Suite 1000, Westminster, Colorado 80021. Precipitation is also transmitted from three locations at the site. The telemetry system is accessible remotely via network infrastructure.

Refer to the Communications Directory section at the front of this O&M Plan for normal and emergency telephone numbers and other methods of communication.

2.4 Cooperation with Other Agencies

2.4.1 U.S. Fish and Wildlife Service (USFWS)

The original OU boundaries of the site have been reconfigured to consolidate all areas potentially requiring additional remedial actions into the COU. The remaining portions of the site were consolidated into the Peripheral OU (POU). The site was declared officially closed on December 7, 2005. With cleanup of the site complete, portions have been transitioned to a National Wildlife Refuge pursuant to the Rocky Flats National Refuge Act of 2001 (Public Law 107-303). USFWS is responsible for the POU property that has been transferred for refuge purposes, while DOE is responsible for the COU and the remainder of the POU not yet transferred. The majority of the structures covered by this O&M Plan are located in the COU. However, several diversion structures and canals/ditches related to the downstream dams within the COU are located in the POU.

2.4.2 Colorado Department of Public Health and Environment (CDPHE) and the U.S. Environmental Protection Agency (EPA)

RFLMA establishes a consultative process in implementing the environmental regulatory requirements at the site. With regard to this O&M Plan, EPA and CDPHE are primarily concerned with water-quality issues. Any discharges from the terminal ponds (Ponds A-4, B-5, and C-2) and the Landfill Pond are conducted in cooperation with these agencies.

DOE, EPA, and CDPHE have agreed to certain notification requirements in the event that emergency conditions require activation of the site's Emergency Response Plan (ERP)

(DOE 2008a). The intent of the agreement is to proactively delineate the "alternative water management practices" and reach agreement on implementation and responses.

2.4.3 State of Colorado Department of Water Resources (State Engineer)

The State of Colorado Department of Water Resources (State Engineer) has jurisdiction over the site dams. Site dams must be managed according to the *Rules and Regulations for Dam Safety and Dam Construction* (State of Colorado 2007).

2.4.4 City and County of Broomfield

On September 26, 2006, DOE signed a Lease Agreement (Agreement; City and County of Broomfield and DOE 2006) with the City and County of Broomfield to comply with the water law and regulations of the State of Colorado as they apply to the holding ponds at the site. Since DOE has implemented a system of holding ponds for the purpose of controlling and testing surface water that collects on the Site, and the water law and regulations of the State of Colorado require that stream depletions resulting from out-of-priority storage of water be replaced, Broomfield agreed to lease to DOE a certain amount of Broomfield's reusable Windy Gap effluent. This water is to be released to the Big Dry Creek Basin to replace depletions resulting from out-of-priority storage in ponds at the site.

To determine the out-of-priority storage in the site ponds, the site must collect pond level data as follows:

- Hourly levels via telemetry for Ponds A-3, A-4, B-5, and the Landfill Pond; and
- Monthly field levels for Ponds A-1, A-2, B-1, B-2, and B-3.

The Agreement requires that several routine reports be transmitted by the site to Broomfield (Section 2.5.4).

2.5 Data Reporting

Several periodic data reports are required for the project. Instructions for collecting the associated data are given in Sections 3.2 and 4.0. Examples of these reports are provided in Appendix L.

2.5.1 Pond Status Report

A monthly Pond Status Report is transmitted via email to the regulatory agencies and interested members of the public (Table 2−2). This report consists of pond levels, piezometer levels, and select summary information for discharges and transfers (Appendix L).

Table 2−2. Pond Status Report Recipients

Contact Name	Agency/Organization	Email Address
Carl Spreng	CDPHE	carl.spreng@state.co.us
Andy Carpenter	Stoller LM	andy.carpenter@gjo.doe.gov
Bob Krugmire	City of Westminster	bkrugmir@ci.westminster.co.us
Craig Hoffman	City of Broomfield	choffman@ci.broomfield.co.us
Clark Johnson	City of Arvada	cjohnson@ci.arvada.co.us
Jeremiah McLaughlin	Stoller LM	jeremiah.mcLaughlin@gjo.doe.gov
Jim Holliday	Woman Creek Reservoir Authority	ownersrep@comcast.net
Kathy Schnoor	City of Broomfield	kschnoor@ci.broomfield.co.us
Larry Kimmel	EPA	kimmel.larry@epa.gov
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Albert Nelson	City of Westminster	ANelson@ci.westminster.co.us
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Scott Surovchak	DOE	scott.surovchak@lm.doe.gov
Shirley Garcia	City of Broomfield	sgarcia@ci.broomfield.co.us
S. Ramer	City of Westminster	sramer@ci.westminster.co.us
Shelly Stanley	City of Northglenn	sstanley@northglenn.org

2.5.2 Pond Discharge Notifications

Prior to a terminal pond discharge, two Pond Discharge Notifications are transmitted via email to the regulatory agencies and interested members of the public (Table 2−3). The first report consists of predischarge sampling dates, pond levels, expected discharge dates, and expected discharge volumes. The subsequent report consists of updated pond levels, expected discharge dates, expected discharge volumes, and analytical data for predischarge samples, including the data validation summary (Appendix L).

Table 2−3. Pond Discharge Notification Recipients

Contact Name	Agency/Organization	Email Address
Carl Spreng	CDPHE	carl.spreng@state.co.us
Mark Aguilar	EPA	aguilar.mark@epa.gov
Vera Moritz	EPA	moritz.vera@epa.gov
Steve Berendzen	USFWS	steve_berendzen@fws.gov
Amy Thornburg	USFWS	amy_thornburg@fws.gov
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Shirley Garcia	City of Broomfield	sgarcia@ci.broomfield.co.us
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Kathy Schnoor	City of Broomfield	kschnoor@ci.broomfield.co.us
Shelley Stanley	City of Northglenn	sstanley@northglenn.org
David Allen	City of Northglenn	dallen@northglenn.org
Bud Hart	City of Thornton	bud.hart@cityofthornton.net
Scott Niebur	City of Thornton	scott.niebur@cityofthornton.net
Cathy Shugarts	City of Westminster	cshurgarts@ci.westminster.co.us
Mark Gutke	JeffCo	mgutke@co.jefferson.co.us
Paul Winkle	Colorado DOW	paul.winkle@state.co.us
David Abelson	Rocky Flats Stewardship Council	dabelson@rockyflatssc.org

2.5.3 Dam Safety Inspection Reports

Requirements for dam safety inspections are determined by the State of Colorado Department of Water Resources (State Engineer) and detailed in the *Rules and Regulations for Dam Safety and Dam Construction* (State of Colorado 2007). The State of Colorado requires a formal safety inspection of site dams, based on hazard classification, every 6 years. DOE may use its own *qualified* engineer, as defined in the regulations. An example Engineer's Inspection Report is provided in Appendix L.

2.5.4 Broomfield Water Lease Reports

As presented in Section 2.4.4, DOE signed an Agreement with the City and County of Broomfield in September 2006 to comply with the water law and regulations of the State of Colorado as they apply to the holding ponds at the site. The Agreement requires that several routine reports be transmitted by the site to the City of Broomfield. The reports are produced in a semiautomated manner using a spreadsheet application that is dynamically linked to the site telemetry system. Examples of these reports are provided in Appendix L and detailed below.

Evaporation estimates will be based on the pool elevation data for each pond (derived from stage-area curves for each pond), and gross evaporation rates for the site area as published in the Evaporation Atlas for the Contiguous 48 United States (NOAA Technical Report NWS33), 1982 (Table 2−4) and using the Colorado State Engineer's Office (SEO) standard procedure for determining monthly net evaporation.

Table 2−4. Estimated Gross Evaporation Rates—Rocky Flats Site

Month	Monthly Distribution of Annual Evaporation[a] (percent)	NOAA TR-33 Annual Evaporation[b] Distributed Monthly (inches/month)	NOAA TR-33 Annual Evaporation[b] Distributed Daily (inches/day)
January	3.0	1.17	0.038
February	3.5	1.37	0.049
March	5.5	2.15	0.069
April	9.0	3.51	0.117
May	12.0	4.68	0.151
June	14.5	5.66	0.189
July	15.0	5.85	0.189
August	13.5	5.27	0.170
September	10.0	3.90	0.130
October	7.0	2.73	0.088
November	4.0	1.56	0.052
December	3.0	1.17	0.038
Annual Total	100.0	39.0	

References:
[a]General Guidelines for Substitute Supply Plans for Sand and Gravel Pits. Submitted to the State Engineer Pursuant to SB 89-120 and SB 93-260
[b]NOAA Technical Report NWS 33 Evaporation Atlas for the Contiguous 48 United States, June 1982. (Annual estimated free water surface evaporation for RFETS area is 39 inches.)

Monthly Reports—Water volume data for all of the Walnut Creek basin ponds will be transmitted electronically from DOE to Broomfield in a standardized report. The report quantifies the amount of change in water volume stored for each of the ponds and estimated evaporative losses since the prior report. In addition, the monthly report includes an estimate of evaporative losses, the total volume change, the outflow volume from terminal Ponds A-4 and B-5, and calculated daily inflow volumes for the preceding month for all Walnut Creek basin ponds.

Biweekly Reports (Ponds A-3, A-4, B-5, and Landfill Pond only)—Water volume data from Ponds A-3, A-4, B-5, and the Landfill Pond will be transmitted electronically from DOE to Broomfield in a standardized report. The report will quantify the amount of change in water volume stored for each of the four ponds since the prior report, as well as the estimated evaporative losses, the outflow volume from terminal Ponds A-4 and B-5, and calculated daily inflow volumes during that time period.

Special Reports for Conditions with Increased Storage (Ponds A-3, A-4, B-5, and Landfill Pond only)—During wet conditions when a specified threshold increase of 1 acre-foot (threshold quantity to be approved by the water administration officials or by the water court) or more in water volume stored in the site ponds has occurred during the prior day, data will be transmitted from DOE to Broomfield in the following manner:

Water volume data from Ponds A-3, A-4, B-5, and the Landfill Pond will be transmitted electronically from DOE to Broomfield in a standardized report. The report will quantify the amount of change in storage volume for each of the four ponds since the day before

the increase-in-storage event began, as well as estimated evaporative losses, the outflow volume from terminal Ponds A-4 and B-5, and the calculated inflow volume. Daily reports will continue to be transmitted electronically from DOE to Broomfield until the daily increase in storage volume is less than a specified amount (to be determined by administrative officials or through a judicial proceeding), on which day a standardized end-of-event report will be transmitted from DOE to Broomfield, including the beginning and ending dates of the event, as well as the daily measured storage volumes, estimated evaporative losses, terminal pond outflow volumes, and calculated inflow volumes that occurred during the event period.

The Agreement also provides language regarding the release of water from terminal Ponds A-4 and B-5 (reproduced from the Agreement):

DOE contemplates it will release water stored in the A- and B-Series ponds after: 1) the pond levels reach a predetermined percentage of capacity that would normally cause initiation of the release process, and 2) the water that will be released to flow off the site has been sampled and tested in accordance with the plans listed above. During routine operations, water will be released from Ponds A-4 and B-5 until they are drawn down to approximately 10 percent of their individual capacities.

a. *If the released water is acceptable to Broomfield in Broomfield's sole discretion, said water may be captured by Broomfield in Great Western Reservoir for any use decreed or otherwise allowed to Broomfield.*

b. *If the water is not acceptable to Broomfield, Broomfield may route said water away from the Great Western Reservoir.*

c. *Broomfield may request that water stored in ponds A-4 or B-5 be released to facilitate operations at Great Western Reservoir if either Pond A-4 or B-5 is filled to at least 20 percent or more of its individual capacity. If the request is implemented by DOE, the water to be discharged from the pond will be sampled and released in accordance with protocols specified in the documents referenced above. During such operations, water will be released from Ponds A-4 and B-5 until they are drawn down to approximately10 percent of their individual capacities.*

DOE will attempt to facilitate the requested release, provided that the release does not conflict with pond operation protocols, regulatory requirements, or violation of water quality standards. However, failure to honor the request will not constitute a breach of this agreement.

2.6 Supporting Documents

The following documents support this O&M Plan:

- *Rocky Flats Site Operations Guide* (DOE 2008b)—Includes detailed information on every aspect of site operations;
- *Emergency Response Plan for the Rocky Flats Site Dams* (DOE 2008a)—Includes detailed information on emergency response actions;
- *Rules and Regulations for Dam Safety and Dam Construction* (State of Colorado 2007); and
- *Dam Safety Manual* (State of Colorado 2002).

Appendix G includes a listing of applicable engineering drawings and reference reports.

3.0 Electrical, Mechanical, and Structural Information

This O&M Plan for the Rocky Flats dams has been prepared to provide the information and data needed by operating personnel for the operation of the project works. This section consists of the project works descriptions and inspection and maintenance instructions. Applicable appendixes include:

- Appendix A Dam Data;
- Appendix C Monthly Observation Report;
- Appendix F Inspection and Maintenance Schedule;
- Appendix G References;
- Appendix I Dam Locations and Access Roads;
- Appendix J Permanent Instrumentation Data; and
- Appendix M Schematic for Current Flow and Water Transfer Network.

The Inspection and Maintenance Schedule is a summary of the recommended observation, inspection, and maintenance frequencies and procedures. The list of references provides dam drawing numbers and titles; engineering report titles; and the names of general contractors, subcontractors, and materials and equipment suppliers for various projects.

These instructions do not contain information on major repairs. Operating personnel at Rocky Flats should not be expected to correct problems that cannot be corrected by following the operating procedures, or by normal maintenance functions, such as lubrication and regular adjustments. Skilled personnel will be needed to make monthly observations, perform more extensive maintenance work, and make necessary repairs. Manufacturers should be contacted for instructions on equipment repair work.

In 1983, signs of distress were noted in Dam B-5. Modifications to this manual were made in 1984 to incorporate repairs and changes in operation procedures. In late 1995 and early 1996, engineering designs were completed for the upgrade of the pond outlet works in the existing A-4 and B-5 dams. An O&M manual to supplement the August 1984 *Operations and Maintenance Instructions for Rocky Flats Surface Water Control Project (Dams & Reservoirs)* was prepared. The supplement is incorporated into this update to the manual. The Dam A-4 outlet modifications were completed in 1996. The B-5 outlet modifications were completed in 1998. An alternate design and modifications to the C-2 outlet were made in 2005, and further minor valve modifications to B-5 were also made at that time. This O&M Plan reflects as-constructed conditions and includes manufacturer's O&M instructions for these modifications.

3.1 Infrastructure Descriptions

3.1.1 Dams and Ponds

Figure 3−1 through Figure 3−12 present photographs of the various dams at the Rocky Flats Site. Dams A-1, B-1, B-2, B-3, B-4, and C-1 (Figure 3−1, Figure 3−5 through Figure 3−8, and Figure 3−10) were built in the 1950s and 1960s as small, poorly compacted, earthen dikes. As part of a project to increase water retention capabilities, the dams were enhanced and enlarged in

1972 and a new dam, A-2 (Figure 3−2), was built. The dams were built from clayey site soils. The enlarged dams, with the exception of Dam A-1, were equipped with internal drains. Dam A-2 was keyed into stable soil and was constructed as a zoned dam, with semipervious sand-clay outer shells and a relatively impervious clay core. Upstream slopes at all dams were designed at 2:1, and downstream slopes at 2.5:1, except A-2, which was designed at 2:1. These dams were designed with features consistent with standard design for long-term water retention, as described above. Historically, these dams have performed acceptably during pool elevation conditions up to their spillways.

The Present Landfill Dam (Figure 3−12) was built in 1974 as part of renovations to the Present Landfill. The Present Landfill Dam was keyed to bedrock and was constructed as a zoned dam from site soils, with semipervious clayey or silty sand and gravel outer shells and a relatively impervious clay core. The upstream slope of the dam was constructed at a 3:1 slope and the downstream at a 2.5:1 slope. The normal maximum water surface elevation, as indicated on the design drawings, was expected to be at the spillway.

Dam A-3 (Figure 3−3) was also built in 1974. Dam A-3 was keyed to bedrock and was constructed as a zoned dam from site soils, with semipervious sandy gravelly outer shells and a relatively impervious clay core. Dam A-3 was also equipped with an internal drain. The upstream slope of the dam was constructed at a 3:1 slope and the downstream at a 2.5:1 slope. Dam A-3 contains features consistent with those designed for long-term storage.

Dams A-4, B-5, and C-2 (Figure 3−4, Figure 3−9, and Figure 3−11) are homogenous embankments constructed of predominantly clayey material obtained from required spillway excavation or borrow areas (initially constructed in 1979). Located at the center of the foundation of each dam is a cutoff trench extending to claystone bedrock for the length of the structure. The 2.5:1 (horizontal to vertical) downstream slopes of the dams are covered with 1 foot of seeded topsoil, while the upstream 2:1 slopes have 18 inches of riprap slope protection underlain by 9 inches of bedding material, except for Dam B-5 as discussed below. The upstream riprap slope protection on Dam A-4 extends down to the berm, and the slope below the berm is protected by seeded topsoil. Dam C-2 has no upstream berm and the riprap extends to original ground. The 20-foot-wide crest of each dam is surfaced with 4 inches of selected roadway surfacing material.

Dam B-5, as modified in 1984, has an upstream slope of 2.5:1 from the crest to mid-height and is covered with at least 12 inches of riprap bedding and 18 inches of riprap and a 5:1 slope from mid-height to the toe with no protective covering. Modifications to the outlet in 1998 included installation of an 8-foot-wide berm covered with riprap running up the central portion of the dam at 3.6:1 feet per feet under the valve stem for support. Upstream of the dam a sand and perforated pipe drain bed was installed to filter remaining sediment and to provide a means to drain the pond below the elevated inlet.

The purpose of Dams A-4, B-5, and C-2 is to retain surface water originating on the site until it is determined that the impounded water is free of contamination and to permit treatment of the water if necessary. These dams were designed for flood retention not for permanent water storage. Flood storage should be released as soon as practical to provide storage for a subsequent flood event. Rocky Flats operating personnel will issue instructions governing testing and

releasing of floodwaters. The ponds formed by Dams A-4, B-5, and C-2 are designed to hold in excess of the runoff produced by a 100-year precipitation event.

In 1991, the Dam B-1 downstream slope was flattened from a 1.5:1 to a 2:1 slope, and clean, free-draining gravel was installed in the toe with a riprap covering to protect against further erosion from B-2 tail waters. In 1995, sand/rock filter blankets were installed at the downstream toe of Dams B-2 and B-4 to control seepage. Sediment removal operations in Ponds B-2 and B-3 in 2005 may have at least partially modified or damaged toe drains at B-1 and B-2.

Modifications to the Dam C-1 structure were completed in 2005 and included removal of the existing outlet structure and filling the existing spillway, and installing a new grouted boulder discharge channel with a stop log structure to regulate the water level and maintain water within the pond. The same type of modification has been designed for Dams A-1, A-2, B-1, B-2, B-3, and B-4 but has not been implemented at the time of this writing.

Pond data, including capacities, elevations, and other pertinent information are provided in the appendixes.

Figure 3−1. Dam A-1

Figure 3−2. Dam A-2

Figure 3−3. Dam A-3

Figure 3−4. Dam A-4

Figure 3−5. Dam B-1

Figure 3−6. Dam B-2

Figure 3−7. Dam B-3

Figure 3−8. Dam B-4

Figure 3−9. Dam B-5

Figure 3−10. Dam C-1

Figure 3−11. Dam C-2

Figure 3−12. Present Landfill Dam

3.1.2 Spillways

The Dam A-4, B-5, and C-2 emergency spillways are ungated, open-channel, earth-lined structures with 3:1 side slopes (Figure 3−13). The bottom widths of the spillways are 150 feet, 80 feet, and 250 feet, respectively. Each spillway was overexcavated by 9 to 12 inches and replaced with seeded topsoil. All three spillway channels have a long, flat section to minimize erosion. In each spillway channel, the flat section has claystone bedrock underlying the topsoil for the most part. The spillways are designed to handle floods in excess of the 100-year event for pre-site reconfiguration conditions. Runoff from a pre-site reconfiguration, probable maximum precipitation, or thunderstorm event will be safely passed through these spillways. Although this would be a rare event, it is not considered an unusual condition.

The Present Landfill Dam emergency spillway is an ungated concrete box culvert and open-channel, earth-lined structure with 2:1 side slopes and a bottom width of 10 feet. The spillway is covered with seeded topsoil. The spillway is capable of handling flows from the 100-year event for pre-site reconfiguration conditions.

Figure 3−13. Dam A-4, B-5, C-2, and Present Landfill Emergency Spillways

The Dam A-3 emergency spillway is an ungated, open-channel, earth-lined structure with 3:1 side slopes (Figure 3−14). The spillway is armored with riprap and bedding, and has a cutoff wall at the downstream edge of the dam crest. The spillway is capable of handling flows from the 50-year event for pre-site reconfiguration conditions.

The A-1, A-2, B-1, B-2, and B-3 emergency spillways are ungated, open-channel, earth-lined structures capable of routing the pre-site reconfiguration conditions 50-year storm in the case of A-1 and A-2, and the 100-year storm in the case of B-3 (Figure 3−14). Due to modifications to the B-1 and B-2 spillways during sediment removal operations in 2005, the spillway capacities are unknown for those dams.

Figure 3−14. Dam A-1, A-2, A-3, B-1, B-2, and B-3 Emergency Spillways

Dams A-2, B-2, and B-3 are equipped with service spillways (Figure 3−15 through Figure 3−17) consisting of corrugated metal pipes with ungated concrete inlets that operate at an elevation and capacity lower than the emergency spillway elevation. The Dam B-4 spillway (Figure 3−18) serves as both the emergency and service spillway, as well as outlet structure, and consists of a concrete box culvert and concrete chute with a flip bucket energy dissipation structure that is capable of routing the 50-year event. The Dam B-1 service spillway was inadvertently grouted partially full during efforts to line the conduit with a plastic pipe and was subsequently grouted full to render it totally ***inoperable***.

Figure 3−15. Dam A-2 Service Spillway (Ungated Concrete Inlet)

Figure 3−16. Dam B-2 Service Spillway (Ungated Concrete Inlet)

Figure 3−17. Dam B-3 Service Spillway (Ungated Concrete Inlet)

Figure 3−18. Dam B-4 Emergency and Service Spillway (Concrete Box and Chute)

3.1.3 Outlet Works

Under each of Dams A-4, B-5, and C-2 is an 18-inch pre-stressed concrete cylinder pipe that serves as an outlet. Each pipe rests on a poured concrete cradle. An inlet structure with a trash rack is connected to each 18-inch pre-stressed concrete cylinder pipe. Each outlet conduit has six concrete cutoff collars spaced at 20-foot intervals. Near the downstream end of each conduit, an 18-inch medium-pressure gate valve is installed. This original outlet valve is buried 4 feet underground near each outlet structure (valves A4-1, B5-1, and C2-1; Appendix M). Each valve is covered with a valve box that has a locking device on the cover. Within a few feet of each box is a section of galvanized pipe embedded vertically in the ground to provide a holder for the valve wrench. A butterfly valve is also bolted on the outlet end of each outlet pipe (valves A4-2, B5-2, and C2-2). Both the gate and the butterfly valves are left open (locked where possible) and should only be used as emergency backup valves. The energy developed by water flowing through each sloped outlet pipe is dissipated in a concrete, impact-type stilling basin. A flow-measuring concrete Parshall flume with a galvanized steel liner is installed downstream of each impact-type stilling basin. The gauge house contains flow monitoring and measuring equipment, while a separate shed houses water quality sampling equipment. Inlet and outlet channels near the flumes have a maximum side slope of 3:1 with a seeded topsoil layer (Figure 3−19 through Figure 3−21).

The primary purpose of the outlet modifications performed in the 1990s and in 2005 at Dams A-4, B-5, and C-2 was to provide upstream control gates at each dam. Secondly, in conjunction with the upstream inlet control, an inlet control structure was provided at a raised elevation to provide controlled detention operation for water-quality purposes. At A-4, a low-level valve was provided to drain the pond below the inlet control structure. At B-5, the existing low-level 6-inch-diameter pipe with a gate valve connected to the inlet structure was left in place, with modification to the drain to add a standpipe with an intake just above the pond bottom. C-2 has no low-level valve.

The control gates for the inlets at A-4, B-5, and C-2 are slide gates (valves A4-MG, A4-WQG, B5-MG, and C2-MG). The face of the gates is specially machined to reduce seepage to a negligible amount (100 to 200 gallons per day). The low-level 6-inch drain gate valve at B-5 also experiences minor leakage. The slide gate operating stems at A-4 and B-5 are located within a synthetic oil-filled encasement pipe. The C-2 gate is hydraulically actuated and also uses a synthetic oil of a different type. Appendix G provides the name and supplier of the synthetic oils. Oil should be checked as part of the regular maintenance schedule.

B-5 can alternatively be pump-transferred to A-4 through an existing pipeline located at the side of the spillway. Two flat areas are located in the pond basin at the spillway to serve as pump stations.

The Present Landfill Dam outlet (Figure 3−22) is a controlled low-level outlet consisting of a 10-inch-diameter ductile iron pipe with a butterfly valve installed on the upstream end (valve DE-S) and gate valve on the downstream end (valve DE-N). The inlet is a concrete structure with a trash rack. Eight concrete cutoff collars are located along the outlet pipe. Normal operations currently consist of continual direct discharge of water from the Landfill Pond to No Name Gulch through the partially open outlet works. The energy developed by water flowing through the sloped outlet pipe is dissipated in a concrete impact-type stilling basin.

Dam A-3 (Figure 3−23) has a controlled low-level outlet consisting of a 16-inch-diameter ductile iron pipe that necks down to a 12-inch-diameter pipe with a gate valve and a butterfly valve (valve A3-4) on the downstream end. A gate value (valve A3-3) is located just upstream of the butterfly valve; this gate valve leaks into the dam structure when closed. As such, ***this gate should remain open at all times***. The inlet is a concrete structure with a trash rack that rests on the bottom of the pond. The energy developed by water flowing through the sloped outlet pipe is dissipated in a concrete impact-type stilling basin. A flow-measuring concrete Parshall flume with a galvanized steel liner is installed downstream of the impact-type stilling basin.

The Dam A-1 outlet structure (valve A1-4), a 48-inch corrugated metal pipe, is grouted shut and is ***inoperable***. The upstream gate (valve A2-3) of the Dam A-2 outlet, a 10-inch ductile iron pipe, has been dismantled and a grout plug installed in the pipe, and is also ***inoperable***. The Dam B-1 outlet, a 10-inch ductile iron pipe with a valve, is ***grouted shut*** from the downstream end to the valve. The Dam B-2 outlet is a 10-inch-diameter ductile iron pipe ***plugged with grout*** on the upstream end; the valve is not known to be operable (valve B2-3). The Dam B-3 outlet (Figure 3−24) is an operational, gated, 10-inch ductile iron pipe with a 2.5-foot riser on the inlet that exits into a 48-inch corrugated metal pipe that also serves as the service spillway (the riser gate [valve B3-3] is maintained in an open configuration). The concrete spillway previously described serves as the outlet for Dam B-4 (Figure 3−18). Dam C-1's 48-inch corrugated metal pipe outlet has been removed and replaced with a channel and stop log structure to attenuate flows through the pond (Figure 3−25). The configuration has been designed so that the stop log structure can be removed in the future so the dam functions as a fully breached structure. The same designs, which would also include removal of existing outlet structures, have been completed for Dams A-1, A-2, B-1, B-2, B-3, and B-4, but have not been implemented at this time.

Dam A-4 Upstream Control Gates and Inlets (Dual Gates at 10% and 20% of Capacity)


Dam A-4 Downstream Impact Basin and Butterfly Valve

Discharge Monitoring Location GS11

Figure 3−19. Dam A-4 Outlet Works

Dam B-5 Upstream Control Gate and Inlet

Dam B-5 Downstream Impact Basin and Butterfly Valve

Discharge Monitoring Location GS08

Figure 3−20. Dam B-5 Outlet Works

Dam C-2 Upstream Control Gate and Inlet

Dam C-2 Downstream Impact Basin and Butterfly Valve

Discharge Monitoring Location GS31

Figure 3−21. Dam C-2 Outlet Works

Present Landfill Dam Upstream Inlet Structure (Butterfly Valve) and Controls

Present Landfill Dam Downstream Impact Basin and Gate Valve Opening

Figure 3−22. Present Landfill Dam Outlet Works

Dam A-3 Downstream Impact Basin and Butterfly Valve

Discharge Monitoring Location GS12

Figure 3−23. Dam A-3 Outlet Works

Figure 3−24. Dam B-3 Outlet Works Riser and Gate Control

Figure 3−25. Dam C-1 Channel and Stop Log Structure

3.1.4 Diversion Structures

The North and South Walnut Creek Diversion Structures (Figure 2−1 [map], Figure 3−26, and Figure 3−27) are concrete walls built across the channels. North Walnut Creek flows can be routed through a 24-inch corrugated metal pipe (single gate [valve A1-1]) into the furthermost upstream dam in the series (A-1), or through dual gates (valves A1-2 and A1-3) to a 42-inch corrugated metal pipeline running on the south side of the A-series dams. South Walnut Creek flows can also be routed through a 24-inch corrugated metal pipe (single gate [valve B1-2]) into the furthermost upstream dam in the series (B-1), or through dual gates (valves B1-1A and B1-1B) to a 48-inch corrugated metal pipeline running on the south side of the B-series dams.

The North Walnut Creek pipeline has valved diversion boxes that allow flow to be routed into Pond A-2 via the A-1 outlet channel (Figure 3−28; valve A2-2), into Pond A-3 just downstream of Pond A-2 (this gate valve [A3-2] is not known to be operable and is currently open), or into Pond A-4 (valve A3-1) through the A-3 spillway (Figure 3−29). The South Walnut Creek pipeline has no such boxes and will only route flows into Pond B-4 just downstream of Pond B-3. The North Walnut Creek Diversion Structure has a capacity of approximately 90 cubic feet per second (cfs) before overtopping and flowing into Pond A-1, which is significantly less than the modeled 25-year post-site reconfiguration storm event peak flows (approximately 190 cfs). The South Walnut Creek Diversion Structure has a capacity of approximately 160 cfs before overtopping and flowing into Pond B-1, which is adequate for a modeled post-site reconfiguration 25-year storm event (approximately 97 cfs).

Figure 3−26. North Walnut Creek Diversion Structure

Figure 3−27. South Walnut Creek Diversion Structure

Figure 3−28. North Walnut Creek Diversion Box to Pond A-2

Figure 3−29. North Walnut Creek Diversion Box to Pond A-3 or A-4

3.1.5 Diversion Dams

The diversion dams (Woman and Walnut Creeks; Figure 3−30 and Figure 3−31, respectively; Figure 2−1 [map]) are constructed as a cutoff wall of caulked interlocking steel sheet piles. The top of the steel cutoff wall is embedded into a 24-inch square concrete cap for the length of the structure. The steel piling extends approximately 15 feet below the concrete cap at the Walnut Creek Diversion Dam. The Woman Creek Diversion Dam steel piling wall extends approximately 8 to 14 feet below the concrete cap and is embedded 12 to 18 inches into claystone bedrock for the length of the structure. The 2:1 upstream slopes have 36 inches of riprap slope protection underlain by 12 inches of bedding material. Upstream of this riprap are ponding areas protected by 6 inches of seeded topsoil. The 3:1 downstream slopes have 48 inches of riprap slope protection underlain by 12 inches of bedding material. The headworks of the Walnut and Woman Creek diversion dams consist of three and seven, respectively, 60-inch corrugated metal pipes with cutoff collars.

The purpose of the Woman and Walnut Creek diversion dams is to divert the 100-year flood run, originating west of the site, through the headworks into the Woman Creek Diversion and McKay Bypass Canals (Section 3.1.6), respectively, passing the flow around Pond C-2 and the A-Series ponds, respectively. Larger amounts of runoff in excess of the 100-year flood will overflow the diversion dam crest.

Figure 3−30. Woman Creek Diversion Dam

Figure 3−31. Walnut Creek Diversion Dam

3.1.6 Diversion Canals

Four canals exist at or near the site: the West Interceptor Canal, South Interceptor Ditch (SID), McKay Bypass Canal, and Woman Creek Diversion Canal (Table 3−1). The locations of the West Interceptor Canal and McKay Bypass Canal are shown on Figure 2−1. Typical sections of the West Interceptor Canal, McKay Bypass Canal, Woman Creek Diversion Canal, and SID are shown on Figure 3−32, Figure 3−33, Figure 3−34, and Figure 3−35, respectively. The SID and Woman Creek Diversion Canal traverse several sizeable areas of unstable slump-prone materials. Several sections along the SID have experienced slumping and a decrease of cross section.

The canals consist of open-channel, earthen cut-and-fill sections interrupted by drop structures and road crossings where needed. Excavated portions of the canals produced materials for construction of adjacent fills, and excess excavation was placed above and outside the required fill lines. Most of the canal slopes were excavated and placed at a 2:1 slope, while unstable areas were flattened to a maximum 4:1 slope. Slopes are stabilized with 6 inches of topsoil that was placed across the entire width of the canal and seeded.

Some of the canals have a considerable drop in elevation from the inlet to the outlet. A portion of the energy created by water dropping in elevation is dissipated by the use of rock grade controls. However, the structures along the McKay Bypass and Woman Creek Diversion Canals have experienced damage during past large flows. Most of the rock grade controls drop 10 feet and have a 1-foot-deep stilling basin at the bottom. A riprap dam was placed at the top of the drop to provide normal velocities and water surfaces in the preceding portion of the canal. The rock riprap dam is required primarily because of the closeness in spacing of some of the structures. The rock grade controls are protected by 24 inches of riprap placed on 12 inches of bedding

material. In some sections of the canals, energy is dissipated by inverted siphon corrugated metal pipe crossings. The inverted siphon pipe crossings take the place of a rock grade control and provide a vehicle crossing. The inverted siphon pipes were used where a crossing or headworks was needed and where excess elevation drop is not available.

Table 3−1. Canal Physical and Hydraulic Characteristics

Canal	Length (feet)	Total Drop (feet)	Maximum Normal Water Depth (feet)	Maximum Normal Flow (cfs)
West Interceptor Canal	784	0.16	3.85	91
McKay Bypass Canal	10,500	260.05	5.82	368
Woman Creek Diversion Canal	2,005	31.36	8.14	1,032
South Interceptor Ditch	6,355	195.37	5.61	327

Figure 3−32. Typical West Interceptor Canal Section

Figure 3−33. Typical McKay Bypass Canal Section

Figure 3−34. Typical Woman Creek Diversion Canal Section

Figure 3−35. Typical SID Section

3.1.7 Functional Channels

Five functional channels (abbreviated as FC-1 through FC-5; Figure 2−1 and Figure 3−36 through Figure 3−39) were constructed during site closure to convey runoff and minimize erosion. The FCs were constructed as either grass-lined, nongrouted riprap or grouted riprap based on gradient and expected flow rates/velocities. Selected physical and hydraulic characteristics for the functional channels are given in Table 3−2.

Table 3−2. Functional Channel Physical and Hydraulic Characteristics

Functional Channel	Length (feet)	Total Drop (feet)	100-Year Peak Flow (cfs)
FC-1	1,138	27	76
FC-2 (upper segment; lower segment)	823; 509	37; 10	72
FC-3	1,554	57	264
FC-4	3,656	107	277
FC-5	1,555	61	37

Figure 3−36. FC-1 Looking NW

Figure 3−37. FC-2 Looking NW

Figure 3−38. FC-3 Looking E

Figure 3−39. FC-4 and FC-5 Looking E

The FCs were designed to adequately convey the 100-year event runoff flows. The rational method described in the *Urban Storm Drainage Criteria Manual, Volume I* (USDCM) (UDFCD 2001) was used to estimate peak flow rates. The maximum watershed size for the rational method varies from 160 acres in the Urban Drainage Manual to 600 acres in *Introduction to Hydrology* (Viessman and Lewis 2003). Since the largest drainage area for the FCs is less than 250 acres, the rational method was used to determine peak runoff rates.

The equation for peak runoff is as follows:

$$Q = CIA \qquad \text{(Equation RO-1 of the USDCM)}$$

Where Q = peak runoff (cubic feet per second)
C = runoff coefficient (dimensionless)
I = rainfall intensity (inches/hour)
A = subcatchment area (acres)

This equation was used to calculate the 100-year runoff rates. The 100-year 1-hour point rainfall for the site (2.7 inches from USDCM, Figure RA-6) and the time of concentration for each drainage basin were used to calculate the rainfall intensity.

The U.S. Army Corps of Engineer's Hydrologic Engineering Center-River Analysis System (HEC-RAS) program was used to model channel hydraulics. HEC-RAS is an interactive, integrated, menu-driven program that uses the standard step method to calculate subcritical water surface profiles. Manning's equation is used to account for channel roughness as it pertains to channel conveyance. Supercritical flow parameters are calculated using the momentum equation. HEC-RAS allows three options for computing the flow profile: subcritical, supercritical, and mixed. For the mixed mode, which was used for the design, the program computes the profile twice. The first calculation uses the subcritical flow regime and the second uses a supercritical flow regime. Of the two regimes analyzed, the regime with the greater specific force was assumed the correct profile.

The Manning's roughness coefficient, n, used for channel design, was obtained from the USDCM. Subcritical flow (typically smooth, nonturbulent flow) occurs when the Froude number (F) is less than 1, critical flow occurs when the Froude number equals 1, and supercritical flow (typically turbulent flow) occurs when the Froude number is greater than 1. Where the flow regime changes from subcritical to supercritical flow (or vice versa), a hydraulic jump occurs, which can be unstable and erosive. Thus, channels were designed at critical flows (F = 1) since the flow can jump quite frequently, leading to unstable, erosive channels. General practice is to design channels so the Froude number is less than 0.8 or greater than 1.2. This confines hydraulic jumps to grade breaks (changes in channel slope) where thickened riprap keys can be provided to counter the potential erosive effects of the jump. For the FC, channels were designed so the Froude number was less than 0.8 or greater than 1.2.

For ease of construction, the minimum channel bottom width was designed to be 8 feet. Note that a 7-foot width could have been used on riprap-lined channels as long as the subgrade bottom width (bottom of riprap layer or bedding layer) was at least 8 feet. In accordance with the USDCM, side slopes were designed to be 4:1 or flatter for grass-lined channels, and 2.5:1 or flatter for riprap-lined channels.

A minimum of 1 foot was added to the 100-year water surface elevations to meet the freeboard criteria of the USDCM. Superelevations at the outside of the channel curves were calculated using Equation MD-9 of the USDCM for subcritical flows and Equation 8.19 of *Urban Flood Channel Design and Culvert Hydraulics* (Guo 2004a) for supercritical flows. Superelevation effects are in addition to the freeboard depth. Cross-waves were checked on curved steep reaches

to verify that the height of the waves was less than the height of the channel depth with freeboard. Cross-wave heights were calculated using the cross-wave calculation program in *Trapezoidal Channel Design and Flow Analysis* (Guo 2004b).

3.1.7.1 Grass-Lined Channels

Per the USDCM, the maximum velocity for grass-lined channels is 5 feet per second (fps) in erosive soils and 7 fps in nonerosive soils. The site has an abundance of Rocky Flats Alluvium, which can be erosive. Thus, 5 fps was used as the maximum velocity for grass-lined channels. In addition, per the USDCM, the maximum Froude number was selected to be 0.5. Section 4.1.6 of the Major Drainage chapter in the USDCM was used to determine if channel bends of grass-lined channels require a riprap lining.

3.1.7.2 Non-Grouted and Grouted Riprap-Lined Channels

Subcritical Flow

In accordance with the USDCM, riprap was used to line channels with Froude numbers between 0.5 and 0.8 and velocities less than 12 fps. Riprap size was determined using Equation MD-13 and Table MD-10 of the USDCM. The Manning's roughness coefficient, n, was calculated using the following equation:

$$n = 0.0395 * D50^{1/6}$$ (Equation MD-14 of the USDCM)

Where D50 = the mean riprap stone size in feet.

Channels lined using riprap with a D50 of 6 inches or 9 inches were mixed with 30 percent (by volume) topsoil and buried with 6 inches or more of topsoil (this mix is referred to as soiled riprap). Grouted riprap was used when the flow velocity was determined to be above the Urban Drainage maximum criteria of 12 fps.

Supercritical Flow

The *Surface Mining Water Diversion Design Manual* (Simons, Li & Associates 1982*)* was developed for steep channel design (supercritical flows). This manual provides charts for determining D50 using the flow rate, channel cross section, and channel slope. It was used to determine the D50 for channels with Froude numbers greater than 1.2 and velocities below 12 fps. Grouted riprap was used when the flow velocity was determined to be above the Urban Drainage maximum criteria of 12 fps.

3.2 Maintenance and Inspection

A regular program of inspection and maintenance is implemented to properly maintain the project works. Regular observations are required to locate potential sources of trouble so that minor corrections and repairs can be made in time to prevent more serious deterioration or damage. Regular maintenance, consisting primarily of good housekeeping, is likewise essential to minimize the major causes of wear and deterioration of equipment and structures.

Instructions for inspections and maintenance, including a brief discussion of the procedures to be followed and a tabular Inspection and Maintenance Schedule, are attached in the appendixes. Detailed instructions and parts lists are given in manufacturers' manuals and bulletins for equipment where available. For convenient reference, the equipment items and respective suppliers are included in Appendix G.

Each operator should become familiar with the structures, equipment, and inspection and maintenance requirements and procedures. The operator has the responsibility of keeping the dams, outlet works, canals, and structures in good operating condition at all times. The operator will make observations where the dismantling of equipment is not required and will make necessary adjustments and repairs that do not require skilled specialized personnel and facilities.

These instructions and the instructions contained in the manufacturers' literature are necessarily general. Experience in working with the structures and equipment may produce additional maintenance procedures or modification of the procedures contained herein. The operator is encouraged to suggest such changes, but they should be adopted only after careful consideration of their possible long-term effects, and after obtaining approval of an engineer who is thoroughly familiar with the design and function of the equipment and structures.

Water level staff gauges of some type are present in all ponds except at Dams B-4 and C-1, since these operate as flow-through structures. These staff gauges are:

- I-beams with numbered face plates (A-4 and B-5);
- Numbered face plates bolted to inlet structures (A-4 and B-3);
- Steel channels with numbered face plates; or
- Fence posts with numbered face plates.

At Dams A-3, A-4, B-1, B-3, B-5, C-2, and the Present Landfill Dam, open-well piezometers have been installed. The water levels in the piezometers should be measured at least monthly. A piezometer record sheet is included in Appendix D. Higher-than-normal piezometer levels should be reported and evaluated immediately. Movement monuments have been installed on the crests of A-4, B-5, and C-2 and should be surveyed at least twice yearly by qualified surveyors and the results reviewed by a qualified engineer. Additional temporary monuments were installed on the downstream face of B-5 in March 2008; these monuments are to be surveyed quarterly until further notice. Inclinometers have also been installed at these dams, one at A-4, two each at B-5 and C-2, which should also be read by qualified personnel and results reviewed by a qualified engineer.

In addition to regular observations by operating personnel, an inspection by an engineer qualified in dam design and inspection should be conducted:

- At least annually for Dams A-3, A-4, B-5, C-2, and the Present Landfill Dam; and
- Every 3 years for Dams A-1, A-2, B-1, B-2, B-3, B-4, and C-1 or more often as special conditions arise.

The engineer may increase the frequency of periodic inspections when conditions warrant.

3.2.1 Operating Records

Records on O&M of the dams must be accurate and current. A sample operations log form is included in Appendix B. A record of precipitation, inflow volumes, and pond level, both upon opening and closing the outlet valve, should be maintained. Operability of remote monitoring equipment should be checked periodically. If the remote monitoring equipment is nonoperable, levels of ponds where inflow is occurring should generally be read weekly; monthly for all others. All observations and monitoring of the dams should be reported. Various record sheets are provided in the appendixes.

In addition to field records and logs, monthly status sheets are sent to the Dam Owner, DOE, CDPHE, the downstream Cities of Broomfield and Westminster, and other interested parties (Section 2.5.1). These status sheets are developed with a spreadsheet that has been specifically developed for pond operations.

3.2.2 Dams and Ponds

The dam embankments, spillways, outlet works, and pond shoreline should be inspected monthly, with general maintenance in the early spring and late fall. A Monthly Observation Report form is included in Appendix C.

Shoreline debris found below the normal operating level should be raked up and removed as required to avoid the possibility of clogging the outlet works.

The riprap protection on the upstream slope of the dam should be inspected at times when the pond is drawn down to a minimum level and after any major windstorm has produced prolonged wave action. The riprap should be maintained in good condition, and rock for repair can be obtained from the Asphalt Paving Company quarry or other quarries of equivalent quality. In cases where the bedding under the riprap has been removed by severe wave action, the bedding should be replaced prior to replacing the riprap. If erosion extends into the embankment beyond the riprap and bedding, the dam engineer should be notified immediately for prompt repair. Weeds and woody plants should be removed from upstream riprap slopes either manually or using an appropriate herbicide in coordination with the Site Ecology Lead and in consideration of water-quality impacts.

The dam embankments should be thoroughly inspected at least once a year after the season's major runoff event(s). When the pond levels reach their highest levels, the downstream slopes and abutments should be inspected for new seepage, damp spots, or swampy areas. In addition, the dams should be closely inspected for any evidence of surface cracking, settlement, or slope changes. In general, any condition that has changed from a previous inspection should be investigated. Embankments should be periodically mowed/weed-whacked to a height of 3 inches to facilitate dam inspections. Mowing/weed-whacking is generally performed annually in July. Deep-rooted woody plants should not be allowed to grow on the dam structure.

3.2.3 Spillways

A certain amount of erosion of the spillways can be expected to occur if a significant amount of water flows through the spillways. Every time a spillway flows, it should be checked for eroded

areas; if the eroded areas extend only into the topsoil, the topsoil need only be replaced and seeded. If erosion is more significant and extends into the underlying soils or bedrock, repairs should be made with the approval of an engineer who is thoroughly familiar with the design and operation of similar structures. Trash or vegetation that might interfere with flow should be removed from the spillway channel. Weeds and woody plants should be removed/cut from riprapped slopes either manually (to 3 inches) or using an appropriate herbicide in coordination with the Site Ecology Lead and in consideration of water-quality impacts. All grass spillways should be periodically mowed/weed-whacked to a height of 3 inches. Mowing/weed-whacking is generally performed annually in July.

3.2.4 Outlet Works

Every time the ponds are drained, the trash rack on the inlet structure should be inspected for accumulation of debris. If enough debris is present to cover approximately half of the area of the trash rack, it should be cleaned. Any large debris, such as logs or branches, should be removed immediately.

Valves should be operated for their full travel distances to ensure proper internal lubrication every year. The outlet structure should be checked after each major flow for large rocks or logs that might be trapped in the structure and would interfere with normal operation. Cleaning sediment from the impact structure is generally not necessary, as running water through the structure will clean it adequately.

The Parshall flume concrete should be checked yearly for any evidence of deterioration, cracking, or heaving, as should all exposed concrete surfaces. Sediment in the flume and larger material should be removed. Trash or vegetation in the outlet channel that could interfere with flow should be removed. All channels to 15 feet upstream of flumes should be periodically mowed/weed-whacked to a height of 3 inches to facilitate flow measurement. Mowing/weed-whacking is generally performed annually in July.

3.2.5 Pipe Crossings and Diversion Dam Headworks

No regular maintenance is expected to be required for structures that use corrugated metal pipe. Inspections should be made after every major runoff event to ensure that no large logs or branches are present that could plug the pipe inlets. Buildup of sediment in the pipes is normal, and it is expected that during high flows water will clean the pipe adequately. If the pipes become clogged because of abnormally large amounts of weeds or sediment, it will be necessary to clean the pipes. Movement of riprap or erosion of side overflows should be checked after a major runoff event.

3.2.6 Diversion Dams

The area immediately upstream of the diversion dams should be inspected annually. Debris found within the normal floodplain that could plug the pipe inlets should be removed.

The riprap protection on the upstream and downstream slopes of the diversion dams should be inspected after every major runoff event. The riprap shall be maintained in good condition, and rock for repair can be obtained from the Asphalt Paving Company quarry or other quarries of

equivalent quality. In cases where the bedding material under the riprap has been damaged, the bedding material should be repaired prior to replacing the riprap.

The concrete pile cap should be checked yearly for any evidence of deterioration, cracking, or heaving.

3.2.7 Canals and FCs

The channels should be inspected after every major runoff event. Problems that result from large accumulation of sediment or debris, slumps, or slides along the channel, or movement of riprap on the drop structures, should be corrected. Particular attention should be paid to the condition of the raised riprap control section at the upstream end of the rock grade controls. Materials may be piped from under rock grade controls by prolonged relatively minor flows in the channels; therefore, grade control structures should be inspected frequently, particularly in those reaches where the drops are close together. Any damage that could affect the structural integrity of the channel, such as cracks or seepage, should be investigated immediately. Trash or vegetation should be removed if the accumulation is sufficient to be a major impediment to normal flow.

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4.0 Monitoring and Instrumentation

The following sections provide detailed field data collection instructions for the following activities:

- Pond elevation monitoring;
- Piezometer elevation monitoring;
- Displacement monitoring;
- Movement monument monitoring;
- Inclinometer monitoring; and
- Seepage monitoring.

4.1 Pond Elevation Monitoring

Pond elevations shall be monitored to determine current pond volumes and remaining capacities.

Monitoring Locations—Elevation monitoring staff gages are located at all ponds except Ponds B-4 and C-1. Pond elevations at Ponds B-4 and C-1 are not measured, as the dams are operated as flow-through structures.

Monitoring Frequency—Pond elevations shall be monitored monthly unless conditions warrant more frequent monitoring. Biweekly pond level readings at Dams A-3, A-4, B-5, and the Present Landfill Dam are required by the Broomfield Water Lease reporting (Section 2.5.4).

Monitoring Equipment and Guidelines

- Resetting of pond elevation stakes that have shifted due to ice, wave action, etc. may need to be periodically performed.

  — Elevation shall be based from control monuments or other features of known elevation that are located at each pond.

  — A series of pond elevation stakes shall be set at each pond to enable measurement at varying water elevations and aid in determining when stakes need to be reset.

- No specialized equipment is required to read the elevation stakes. Pond elevation monitoring shall be performed under the following guidelines:

  — Stakes are marked to tenths or hundredths of feet. The foot markings may be indicated by the full elevation marking or the last two significant figures of the elevation.

  — The water level shall be estimated based on available markings: to the nearest 0.025 foot for tenth markings, and to the nearest 0.01 foot for hundredth markings.

  — If the stakes have shifted, a best estimate of the pond elevation shall be made.

Field Work Documentation—Field measurements shall be recorded on a data sheet or in a logbook. Examples of these field data sheets have been provided in Appendix D.

Evaluation and Reports

- Pond elevations shall be evaluated per the ERP. If a change in action level is required, members of the Dam Response Team will complete the appropriate notifications.
- The reports for pond elevation monitoring are the computer-generated spreadsheets "Rocky Flats Pond Status." The elevations of the ponds are entered on these sheets in the Pond Model spreadsheet; information including volume, percent full, and other pertinent data is automatically calculated by the spreadsheet. Additional notes and information regarding inflows, discharges, and precipitation shall be entered as appropriate.
- Copies shall be distributed, typically by email, to CDPHE, Cities of Broomfield and Westminster, DOE, and other interested parties (Section 2.5.1). Hard and computer copies should be maintained for record purposes. Command buttons are available on the introduction page of the spreadsheet that automatically create a new file and print the status sheet, with or without the piezometer history sheets, for distribution.
- A detailed, comprehensive, year-end report that includes descriptions, evaluations and analyses, and graphs of the pond level fluctuations for the year should be prepared. This report is typically prepared in support of formal dam inspections.

4.2 Piezometer Elevation Monitoring

Piezometer elevations shall be monitored to determine current water surface elevations as an indication of pore water pressure conditions within the dam.

Monitoring Locations—Piezometers are located at Dams A-3, A-4, B-1, B-3, B-5, C-2, and the Present Landfill Dam (Figure 4−1, Appendix J, and Appendix K).

Monitoring Frequency—Piezometer elevations shall be monitored monthly unless conditions warrant more frequent monitoring.

Monitoring Equipment and Guidelines—A water level indicator is required to measure the piezometer water elevations. Piezometer elevation monitoring shall be performed under the following guidelines:

- Depth to water, from the top of the piezometer casing, shall be determined for each piezometer with a water level indicator by dropping the probe down the piezometer well until the alarm sounds, slowly reeling in the line until the alarm stops, and determining the exact spot on the line at which the alarm began. This is the point at which the electrode is just touching the water in the well. The length of the line at that point shall be measured to the nearest hundredth of a foot.
- The depth to the water shall be subtracted from the elevation of the top of each piezometer casing to determine the elevation of water in the piezometer. The casing elevation is located on the Piezometer Field Sheet (Appendix D), indicated in mean feet above sea level.

Field Work Documentation—Field measurements shall be recorded on the Piezometer and Pond Levels Field Sheet at the time of the observation. Example field data sheets are available in Appendix D.

Evaluation and Reports

- Piezometer elevations shall be evaluated per the ERP. If a change in action level is required, members of the Dam Response Team will complete the appropriate notifications.
- The reports for piezometer elevation monitoring are the computer-generated spreadsheets "Rocky Flats Pond Status." The elevations of the piezometers are entered on the "FieldPiezTerm" and "FieldPiezInt" sheets in the Pond Model spreadsheet; information including volume, percent full, and other pertinent data is automatically calculated by the spreadsheet. Additional notes and information regarding inflows, discharges, and precipitation shall be entered as appropriate.
- Copies shall be distributed, typically by email, to CDPHE, Cities of Broomfield and Westminster, DOE, and other interested parties (Section 2.5.1). Hard copies and computer copies should be maintained for record purposes. Command buttons are available on the introduction page of the spreadsheet that automatically create a new file and print the status sheet with the piezometer history sheets for distribution.
- A detailed, comprehensive, year-end report that includes descriptions, evaluations and analyses, and graphs of the piezometer level fluctuations for the year should be prepared. This report is typically prepared in support of formal dam inspections.

4.3 Displacement Monitoring

Displacements in the dam embankment and/or concrete structures associated with the dams should be evaluated to identify potential problems before they threaten the safety of the dam.

Monitoring Locations—Displacements shall be monitored where and when they occur.

Monitoring Frequency—Displacements on terminal dams shall be monitored annually or more frequently if conditions warrant (see the ERP).

Monitoring Equipment and Guidelines—Displacement monitoring shall be performed under the following guidelines:

- Cracks caused by displacement of the dam shall be monitored by driving stakes/markers on both sides of the crack and each end. Cracks in concrete shall be monitored by spray-painting markers on the concrete on both sides of the crack and each end.
- Horizontal displacement shall be measured by using a tape measure to determine the initial distance between the markers and subsequent distances, or the width of the crack and subsequent widths at the marker in concrete structures, in order to calculate the amount of additional displacement between the markers.
- The ends of cracks shall also be marked to determine if the length of the crack is changing.
- Vertical displacement shall be measured using a carpenter's level and tape measure to determine initial distance between the tops of the markers and subsequent distances, in order to calculate the amount of additional displacement.

Field Work Documentation—Field measurements should be recorded on field sheets or in logbooks at the time of the observation.

Evaluation and Reports—An evaluation and report shall be generated for displacement monitoring. This report is typically prepared as part of the annual dam inspections. Displacements with significant changes should be evaluated by the Dam Engineer.

4.4 Movement Monument Monitoring

Dam movement monuments were installed on Dams A-4, B-5, and C-2 in 1993 to allow for a quantifiable survey of horizontal and vertical movement in the dams. Monuments installed were "Bernsten Top Security," high-precision, and three-dimensional accuracy. The monuments were constructed to reduce the effect of environmental conditions by encasing the monument in a protective polyvinyl chloride (PVC) case with lid; installing a greased, finned sleeve; and driving the monument to refusal. Additional temporary monuments were installed on the downstream face of B-5 in March 2008; these monuments are to be surveyed quarterly until further notice. An experienced surveyor shall perform field monitoring of movement monuments.

Monitoring Locations—On Dam A-4, a radial monument layout was installed to accommodate the curve of the dam crest, with five monuments on the dam crest at approximately 150-foot intervals; two control points are located off the dam crest. On Dam B-5, movement monuments were installed in a straight-line/baseline configuration with two monuments on the dam crest at approximately 140-foot intervals; two control points are located off the dam crest. The additional temporary B-5 monuments were installed in an essentially straight line extending from the crest (near inclinometer B5-I2) to the toe in a north-northwest direction. On Dam C-2, movement monuments were installed in a straight-line/baseline configuration with five monuments on the dam crest at approximately 200-foot intervals; two control points are located off the dam crest. See topographic maps of the dams with locations of movement monuments (Figure 4−1 and Appendix J).

Monitoring Frequency—The primary movement monuments shall be monitored twice a year, in June and December, unless more frequent monitoring is considered necessary (i.e., in extremely high pool conditions, following heavy rains or flooding, following an earthquake, or the appearance of potential structural cracking). The additional B-5 monuments are to be surveyed quarterly until further notice.

Monitoring Equipment and Guidelines—A survey of the movement monuments at each dam shall be completed under the direction and supervision of a licensed land surveyor. The fieldwork shall be completed by surveyors who understand statistical reduction of error by repetitive measuring techniques. Initial baseline readings were taken and subsequent readings shall be taken using the following described guidelines and meeting the stated accuracy requirements:

- Vertical location data for all of a dam's movement monuments shall come from a spirit level loop run through the monuments. The surveyor will use procedures that will produce repeatable results that meet a second order accuracy requirement.

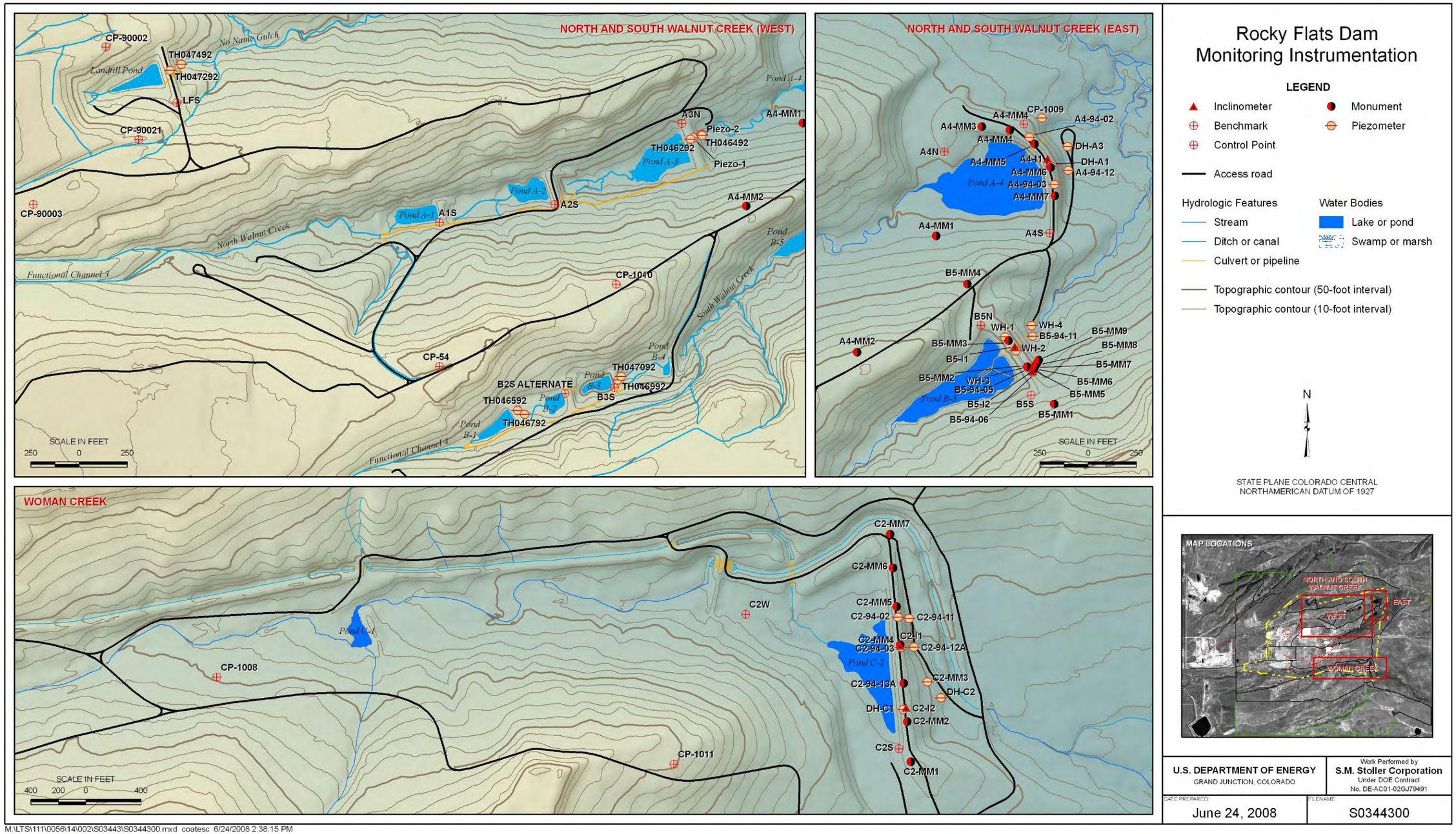

Figure 4−1. Rocky Flats Dam Monitoring Instrumentation

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- Horizontal location data for Dams B-5 and C-2 movement monuments shall be measured as offsets from a consistent baseline with a minimum three-second accuracy gun. This will provide horizontal location data of the fill slope monuments relative to the baseline. The surveyor will use procedures that will produce repeatable results that meet a second order accuracy requirement.
- Horizontal location data for Dam A-4 movement monuments shall be obtained from a radial distance check.

  — Set up on one of the off-dam monuments and check the distance to the other off-dam monument. This provides an electronic distance meter calibration check.

  — Measurements shall be taken to the crest monuments. Matching prisms to tribrach and tripod, and then placing those matched sets on the same crest monuments every survey session, is recommended to minimize measurement errors due to target variation. The surveyor will use procedures that will produce repeatable results that meet a third order accuracy requirement.

Field Work Documentation—Field measurements shall be documented by field notes kept by standard survey techniques.

Evaluation and Reports

- The surveyor shall provide notes and/or results showing field measurements and clarifying the delta measurement from the initial or baseline readings. Qualified personnel shall evaluate the movement monument fieldwork results by entering data into the spreadsheet "Rfpcmon_new.xls" and evaluating the charts and graphs for excessive movement and trends in movement. If a change in action level per the ERP is warranted, appropriate notifications should be made.
- The report for movement monument monitoring shall be the graphs and charts contained within the spreadsheet showing the results of the monitoring and any comments.
- A report shall be generated for monument monitoring. This typically is done in the annual dam inspection report.

4.5 Inclinometer Monitoring

Inclinometers were installed at various locations along the crests of Dams A-4, B-5, and C-2 in 1994 to allow for quantifiable measurement of internal movement in the dam embankments. The inclinometer system consists of a 2.75-inch outside diameter. ABS casing with grooves on the inside at the quarter points, aligned perpendicular and parallel to the dam axis. Inclinometers were installed in near-vertical drill holes to bedrock during field investigations for a geotechnical evaluation. Experienced personnel should perform field monitoring of inclinometers.

Monitoring Locations—One inclinometer was installed at Dam A-4, and two inclinometers were installed at both Dams B-5 and C-2. At each dam, an inclinometer was installed near the dam's maximum section. At Dam B-5, an additional inclinometer was installed at the southern portion of the dam in an old landslide area. At Dam C-2 an additional inclinometer was installed at the southern portion of the dam due to the long length of the dam. Topographic maps of dams indicate approximate locations of inclinometers (Figure 4−1 and Appendix J).

Monitoring Frequency—The inclinometer casings shall be monitored twice a year, in June and in December, unless more frequent monitoring is considered necessary (i.e., in extremely high pool conditions, following heavy rains or flooding, following an earthquake, or the appearance of potential structural cracking).

Monitoring Equipment and Guidelines—Readings and data reduction shall be performed by personnel experienced in the use of an inclinometer probe and its data reduction. An inclinometer probe shall be used, in accordance with manufacturer's directions and previous readings, to traverse the length of the casing to determine the casing profiles in the two perpendicular directions. For all inclinometers the A0 direction is downslope; top/bottom depths and reading intervals are given in Appendix J.

Field Work Documentation—Field measurements shall be recorded in the data recorder module for the inclinometer probe.

Evaluation and Reports

- Data shall be downloaded from the data collector with "DMMWin" software and the data subsequently imported into "Digipro" software for graphing and evaluation. Qualified personnel shall evaluate the inclinometer results as monitoring is performed for excessive movement and trends in movement. If a change in action level per the ERP is warranted, appropriate notifications shall be made. Inclinometer movement evaluation shall be based on comparison of current profiles with the initial profile, as well as the previous profiles, to determine if significant changes have occurred.
- The report for inclinometer monitoring shall be graphs showing the results of the monitoring and any comments.
- A report shall be generated for inclinometer monitoring. This typically is done in the annual dam inspection report.

4.6 Seepage Monitoring

Seepage through the dams through drain systems and wet areas on the downstream slope, abutments, and toe should be monitored to determine seepage patterns, identify and correct potential problems before they threaten the safety of the dam if possible, and identify conditions that threaten the safety of the dam.

Monitoring Location—Currently, Dams A-1, A-2, A-3, B-1, B-2, B-3, B-4, and C-1 have existing seeps. Additional seepage that may occur shall be monitored as indicated in these guidelines.

Seepage should be monitored annually during dam inspections unless conditions indicate more frequent monitoring is appropriate (see the ERP).

Monitoring Equipment and Guidelines—Seepage monitoring shall be performed under the following guidelines:

- If an area on a dam is damp, the wet area shall be staked out and the length and width measured.
- The quantity of flow shall be measured when possible. When the seepage shows a measurable quantity of flow, the rate of flow shall be monitored by creating a drop in the drainage channel and installing either a weir, flume, or pipe. When installation of a flow-measurement device is not possible, a "bucket-and-stopwatch" and/or visual estimation may be used.

  — Flow measurements for weirs and flumes shall be calculated from the stage height of water flowing through the device.

  — Flow from pipes shall be measured by using a bucket and stopwatch to catch a known volume of flow in a given time and calculating the flow rate.
- If flows are unmeasurable, the quantity shall be estimated or the degree of wetness described.
- Seepage quality (i.e., turbidity) shall be observed and jar samples taken as appropriate.
- Subsequent monitoring shall indicate any changes in the above items.

Field Work Documentation—Field measurements shall be recorded on field sheets or in a logbook.

Evaluation and Reports—An evaluation and report shall be generated for seepage monitoring. This report is typically performed as part of the annual dam inspections. Seeps with significant changes or unusually high flow rates should be evaluated by the Dam Engineer.

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5.0 Pond Operations

This O&M Plan has been prepared to provide the information and data needed by operating personnel for the operation of the project works. This section consists of instructions for normal operations and procedures to be followed in the event of abnormal operation. Applicable appendixes include:

- Appendix A Dam Data;
- Appendix B Operation Log;
- Appendix D Piezometer and Pond Levels Field Sheet;
- Appendix E Flume Ratings;
- Appendix G References;
- Appendix H Capacity Charts and Graphs;
- Appendix I Dam Locations and Access Roads;
- Appendix K Piezometer Summary Data; and
- Appendix M Schematic for Current Flow and Water Transfer Network.

The Operation Log or a logbook is a suggested form for keeping records of routine operation of the dams and ponds. The list of References provides dam drawing numbers and titles; engineering report titles; and the names of general contractors, subcontractors, and materials and equipment suppliers for various surface water projects. The outlet works rating curves are contained within the referenced drawing series where data are available and applicable. The pond areas and capacities at various pond levels are shown on the Capacity Charts herein.

Operations are described as "normal," "elevated awareness," or "emergency" based on a combination of retained volume, weather conditions, dam safety concerns, and water quality. Normal operations are defined as those operations that are conducted on a routine and relatively continuous basis. Emergency operations (see the ERP) are defined as specific actions or operations taken in response to abnormal, nonroutine occurrences. The transition from normal to emergency operations occurs in response to specified action levels, or in response to confirmed or suspected water contamination.

Action levels are determined by dam and pond conditions at which operational decisions become less of a function of water quality considerations (as for normal operations mode) and more of a function of weather conditions and dam safety concerns. In addition, water will be discharged in deference to water quality or pond volume in an emergency operation to prevent dam failure. Of the seven action levels (designated 0 through 6), only two action levels (4 and 5) have general applicability to emergency conditions posing imminent threat to dam and pond integrity:

- **Action Level 4** is triggered by pond conditions that potentially threaten the integrity of the dam and could result in failure, and any additional water inputs or minor storm events will result in overtopping of the dam.

  Monitoring frequency for pond levels and dam conditions is increased to daily, and weather forecasts are immediately evaluated. If minor dam problems are observed, and precipitation is forecasted to be minimal, normal operations mode is maintained. If significant dam

problems are observed, or significant precipitation is forecast, emergency operations mode is initiated.

- **Action Level 5** is triggered by pond conditions more serious than Action Level 4 and may include seepage and overtopping of the dam.

  Monitoring of pond levels and dam conditions are conducted every 8 hours, and emergency operations are initiated unless extenuating circumstances exist. Extenuating circumstances may include:

  — Positive knowledge of unacceptable concentrations of contaminants in the pond. In this case, transfers or discharges will be postponed until the last possible moment, unless dam safety considerations take precedent.

  — Analytical results demonstrating acceptable water quality are received concurrent with reaching the action level, no dam problems are observed, and no precipitation is forecast. In this case, normal operations will be followed.

Action Level 6 is actual failure of the dam and uncontrolled release of water, sediments, and dam materials to the downstream watershed. All emergency operations are subject to modification by the ERP.

In case of discrepancies between the above-described operations and the ERP, the ERP will take precedent.

5.1 Operating Instructions

The operating instructions are intended to cover normal operating functions of the Rocky Flats Surface Water Control Project. Instructions for normal operation in this section are limited to the outlet works valves of the dams because of the inherent automatic operations of the remainder of the project. Floods in excess of the pre-site reconfiguration 100-year event, up to the probable maximum flood, will pass safely over the emergency spillways at Dams A-4, B-5, and C-2, and lesser storms in the remainder of the dams as indicated in Section 3.1.2. Should emergency spillway flows occur, the flow over the spillway should be observed until such flow stops. After cessation of the flow, the spillway should be inspected for damage and repairs made as discussed in Section 3.2.3. The outlet works valves are not required to be operated during spillway operation; however, outlet works may be used to lower pond levels at acceptable drawdown rates if the action can be performed ***safely***. Operating personnel should not attempt to repair malfunctioning mechanical equipment. Such repairs require the services of skilled personnel.

5.1.1 Ponds

The water storage elevation should generally be maintained at less than 50 percent of pond capacity on each dam. This water level should typically be exceeded only for storm containment for short time intervals. The water levels in the ponds should not be drawn down faster than a rate of 1 foot per day except under emergency situations, when the integrity of the dam is threatened. Discharge rates, which correspond to a drawdown rate of 1 foot per day for each pond, are modeled with a spreadsheet that has been developed to aid in pond operations. In the case of Dam B-5, the upstream slope has been flattened to permit an increase in the drawdown whenever the pond level is below elevation 5,792 (30.5 percent of capacity), if necessary.

Frequent use of rapid rates, in excess of 1 foot per day, can increase the risk of localized sloughing of the embankments and may cause increased sloughing of the unstable pond slopes.

5.1.2 Outlet Works

The slide gate operators at A-4 and B-5 are hand wheels located at the crest. Dam A-4 contains a 24-inch-diameter main gate (valve A4-MG) and an 8-inch water quality gate (valve A4-WQG). Only one gate at a time should be operated to release water from Pond A-4. Dam B-5 has one 12-inch-diameter slide gate (valve B5-MG). The Dam C-2 slide gate (valve C2-MG) is operated with a hydraulic hand pump located in a vault in the C-2 crest. A switch on the pump must be set to the close or open position prior to operating the hand lever on the pump. To make desired releases, the slide gates should be partially opened and the flow out of the pond observed at the staff gauge on the flume and the valve adjusted to produce the desired flow rate. A sufficient amount of time should be allowed between valve adjustments to allow the flow to stabilize before reading the flume.

Access to gate valves on the downstream end of the outlet pipes at A-3, A-4, B-5, and C-2 is through a locking cover on a valve box located several feet upstream of the end of each outlet (valves A4-1, B5-1, and C2-1). The valves are operated by the 6-foot T-handle valve wrench located in the holder between the valve box and outlet structure. These valves are not currently used and are left in the open position unless failure of the primary valve necessitates using them as an emergency backup. The Dam A-3 gate valve (valve A3-3) leaks into the dam structure when closed—***this gate should remain open at all times***. Each of these dams is also equipped with a butterfly valve located on the downstream end of the outlet pipe (valves A3-4, A4-2, B5-2, and C2-2). The butterfly valve is operated with the same or similar valve wrench. At Dam A-3, this butterfly valve is the primary operating valve for the outlet; and at other dams, it is left open and used only as emergency backup.

At the Present Landfill Dam, a hand wheel located on the crest operates the upstream butterfly valve (valve DE-S). The downstream gate valve (valve DE-N) is equipped with a hand wheel located inside a manhole several feet upstream of the end of the outlet. To initiate discharge through the outlet when the valves are closed, the **downstream valve must be opened prior to opening the upstream valve** or a water hammer will occur.

In Dams A-4, B-5, C-2, and the Present Landfill Dam, a pool will develop between the inlet elevation and the bottom of the pond. Dams A-4 and B-5 have drain valves in addition to the slide gate inlets (two inlets for Dam A-4). To drain this pool at A-4 and B-5, the drain bed valves can be used. Water below the inlet elevation at C-2 and the Present Landfill Pond will have to be pumped if complete draining is necessary. The Present Landfill Dam and Dam C-2 do not have drain valves. The A-3 inlet is located on the pond bottom such that no pool will develop.

The drain valve for Dam A-4 is a 4-inch-diameter valve. The operating stem for the A-4 drain valve extends to just above the main inlet, and a 2-foot-long operating “key” is provided with the valve. The key is stored near the hand wheel at the crest, and uses a standard 2-inch nut connection. The Dam B-5 drain valve (6-inch-diameter) is located within the concrete tower structure. The operating stem is extended vertically to near the top of the concrete tower just above the water quality perforations. An opening is cut in the trash rack/safety grating to allow use of the drain valve key. An existing filter drain system that includes four branches of slotted

PVC drain pipe installed in a filter drainage sand and a vertical riser pipe that extends approximately 2 feet above the existing pond bottom provides inflow to the drain valve. These drain valves should not be operated except in the event of draining the ponds below the primary operating levels. This is anticipated only for maintenance purposes of the structures.

Under normal operations, Pond A-1 is discharged by pumping into the North Walnut Creek Bypass Pipeline diversion box to Ponds A-2 or A-3, or through its spillway into Pond A-2. Pond A-2 is discharged by pumping through its service spillway to Pond A-3. Pond B-1 is discharged by pumping through its spillway to Pond B-2; alternatively, B-1 can be pumped to a manhole on the South Walnut Creek Bypass Pipeline (located in the upstream end of the B-1 spillway). Pond B-2 is discharged by pumping through its service spillway to Pond B-3. Pond B-3 is discharged through the 10-inch overflow standpipe riser equipped with a gate valve (valve B3-3) with the operator located on the upstream face of the dam; this valve is typically left open so the dam performs as a flow through structure. Ponds B-4 and C-1 perform as flow through structures and require no special operation to discharge. These dams were not designed for rapid drawdown rates. Preliminary design documents indicate a rate of 6 inches or less per day was expected to be used. Typically, drawdown rates of up to 1 foot per day have been used for Rocky Flats dams, per recommendations for later Rocky Flats dams and the historical performance of these dams. The semipervious nature of the Dam A-2 outer shell may provide capability for somewhat faster drawdown rates. However, the Dam A-2 outer shell is not a completely free-draining material, and the upstream slope is relatively steep, so that excessive drawdown rates are likely to cause, at a minimum, shallow localized upstream slope failures.

To prevent clogging and facilitate later inspections, the pipe and outlet valves at some of the dams are a larger diameter than required for almost all operating conditions. Water released from the ponds should be controlled such that the **drawdown rate is limited to 1 vertical foot per day.** Drawdown rates more rapid than 1 foot per day can affect the stability of the dam, resulting in slumps or landslides on the face of the dam. The semipervious nature of the outer shells, as well as the relative flatness of the slopes of Dam A-3 and the Present Landfill Dam, may provide for drawdown rate capabilities in excess of 1 foot per day. However, these outer shells do not consist of completely free-draining materials, and overly excessive drawdown rates may cause, at a minimum, shallow localized upstream slope failures. The valves on dams with operating outlets may only be fully opened when making water releases if the water level in the pond is quite low or the integrity of the dam is threatened. Extra capacity is generally available in the flumes in the event rapid evacuation of the pond becomes necessary. Maximum discharge through the outlet works should be restricted to emergency situations. Operating experience will indicate the maximum rate of outflow that can be maintained without undue downstream channel erosion. Key operating parameters for each pond, including (1) stage, storage, and surface area, (2) outlet discharge rating curves, and (3) percent openings to limit drawdown to 1 foot per day, are provided in the design drawings listed for each dam and in the appendixes. Discharges should be monitored at least daily, and the operations should be recorded on a log form similar to that included in the appendixes.

5.1.3 Unusual Conditions

Unusual conditions are defined as an occurrence not normally encountered in the routine operation of the dams and ponds that may endanger the dams or necessitate revision of the operating procedures. Examples of unusual conditions include floods or evidence of riprap

movement, surface cracking, or slope changes in the dams; significant change in quantity or color of seepage flows from the dams or new damp spots or swampy areas that develop near the dams; deflection of cutoff walls or pipe movements; landslides or earthquakes; and structural damage or operational failures of equipment. When unusual conditions occur or are encountered during the routine operation of the dams and ponds, operating personnel must immediately take appropriate precautionary and protective action and then report the conditions promptly. Reports should be made to the dam owner or their representative, or a higher authority, by the most rapid means of communication commensurate with the seriousness of the unusual condition. Use the ERP to determine the appropriate action level and actions to be taken for unusual conditions.

Reports unusual conditions should be accurate and as complete as possible. They should include at least (1) a description of the unusual condition, (2) remedial measures taken or planned, (3) assistance that may be needed, and (4) an estimate of the probable duration of the unusual condition. Further developments, including the end of the unusual condition, should be described in follow-up reports. The follow-up report should be dispatched as soon as possible.

Reports should include measured information to the extent practical. Estimates by personnel untrained in handling unusual conditions can be unreliable and misleading. Reports should include the following:

- Record of date and time of observations;
- Measured location of unusual condition with respect to permanent landmarks or project features;
- Measured extent of unusual condition, such as length and width of newly identified features;
- Staking and/or measurement of seepage flow, or other quantification of unusual conditions, when first observed so that possible changes in area or flow rates can be evaluated later; and
- Site photography if practicable. Placement of hard hats or other well-known size standard in each photograph will provide scale.

If unusual conditions are such that downstream inhabitants or property owners will be or are likely to be threatened, they should be warned. State and county law enforcement offices and local radio stations should be notified if it becomes apparent that pond releases may cause downstream flooding. Use the ERP to determine the appropriate notifications and personnel that will make the notifications.

5.2 Present Landfill Pond Management

The Present Landfill Pond receives direct precipitation and runoff from approximately 12.1 acres and effluent flows from the Present Landfill Treatment System (PLFTS). Operations information for the Present Landfill Pond is provided in Table 5−1.

Table 5−1. Present Landfill Pond Operations Information

	Elevation (feet)	Volume (MG)	% Full	Ops Mode
Maximum (spillway elevation)	5,921.0	8.74	100	Emergency
Action Level 5[a]	>5,920.0	>7.87	90	Emergency
Action Level 3/4[a]	5,919.0	7.07	80	Elevated Awareness
Preferred Max. Elevation	5,914.7	4.38	50	Normal
Normal Elevation (flow-through; outlet elevation)	5,907.3	1.86	21.3	Normal
Minimum Elevation	5,901.6	0.87	10	Normal
Pond Management Sequence: Present Landfill Pond to No Name Gulch (discharge)				

[a]For reference only. Action levels are determined by pond and piezometer elevations, as well as dam conditions.
MG = million gallons

5.2.1 Normal Operations

Past operation at the Present Landfill Pond prior to closure was to transfer water to Pond A-2 and eventually to A-3 for analysis and eventual discharge. Transfer lines have been removed, and normal operations now maintain an open outlet works with direct discharge into No Name Gulch and Walnut Creek.

A normal pool level of 21.3 percent will typically be maintained when the Present Landfill Pond is in a flow-through configuration. However, the Present Landfill Pond may be periodically maintained at higher levels, with the outlet valve closed, for wetland enhancement.

Flow-through operations may be terminated, after consultation between the RFLMA Parties, should water quality results from the Present Landfill Pond suggest the water is unacceptable for discharge. The sampling, data evaluation, and decision rule regarding the Present Landfill Pond and PLFTS are detailed in RLFMA and the Rocky Flats Site Operations Guide (RFSOG) (DOE 2007, 2008b).

Notification of the Present Landfill Pond operations will include the following guidelines:

- Operations personnel will provide, at a minimum, DOE, CDPHE, the Cities of Broomfield and Westminster, and EPA with the Rocky Flats pond status approximately monthly (Section 2.5.1). Pond and piezometer levels and dam observations shall be field-collected once per month at a minimum and more frequently where conditions or action levels warrant.

5.2.2 Emergency Operations

The Present Landfill Pond will be discharged regardless of water quality under the following conditions:

1. The water elevation is 1 foot from the spillway elevation (Action Level 4), and further precipitation or inflow is predicted, or
2. The water elevation is less than 1 foot from the spillway elevation and uncontrolled overflow is imminent, or
3. An emergency condition requiring immediate discharge exists, per the ERP.

The above emergency operations are subject to modification by the ERP. In case of discrepancies between the above-described operations and the ERP, the ERP will take precedent.

5.3 Pond A-1 Management

Pond A-1 will receive water from direct runoff and occasional diversions of North Walnut Creek for wetland enhancement. Pond A-1 is generally maintained and used as a secondary storage pond for the North Walnut Creek drainage. Operations information for Pond A-1 is provided in Table 5−2.

Table 5−2. Pond A-1 Operations Information

	Elevation (feet)	Volume (MG)	% Full	Ops Mode
Maximum (spillway elevation)	5,929.1	1.40	100	Emergency
Action Level 5[a]	>5,828.1	>1.06	76	Emergency
Action Level 3/4[a]	5,827.1	0.75	54	Elevated Awareness
Preferred Max. Elevation	5,826.9	0.69	50	Normal
Normal Transfer Elevation	<5,826.4	<0.56	<40	Normal
Minimum Elevation	5,824.5	0.14	10	Normal
Primary Pond Management Sequence: A-1 to A-3 to A-4 to North Walnut Creek (transfer) Secondary Pond Management Sequence: A-1 to A-2 (transfer)				

[a]For reference only. Action levels are determined by pond and piezometer elevations, as well as dam conditions.
MG = million gallons

5.3.1 Normal Operations

The preferred operation at Pond A-1 is to transfer water to Pond A-3 for eventual discharge.

A functional outlet is not available at Pond A-1. Water transfers from the pond must be accomplished with portable pumping equipment. Water can be pumped to the diversion box on the North Walnut Creek Bypass Pipeline, subsequently flowing to Pond A-3.

Transfer will normally be initiated at any time the pond approaches 40 percent of volume. No sampling is required prior to transfer operations.

Notification of Pond A-1 operations will include the following guidelines:

- Operations personnel will provide, at a minimum, DOE, CDPHE, the Cities of Broomfield and Westminster, and EPA with the Rocky Flats pond status approximately monthly (Section 2.5.1). Pond levels and dam observations shall be field-collected once per month at a minimum and more frequently where conditions or action levels warrant.
- Pre-notification to DOE and others of transfer between interior ponds is not generally required. At a minimum, transfers will be noted on the Pond Status sheet.

5.3.2 Emergency Operations

Pond A-1 will be transferred to Pond A-2 or A-3, regardless of water quality constraints listed above, under the following conditions:

1. The water elevation is 1 foot from the spillway elevation (Action Level 4), and further precipitation or inflow is predicted, or
2. The water elevation is less than 1 foot from the spillway elevation and uncontrolled overflow is imminent, or
3. An emergency condition requiring immediate discharge exists, per the ERP.

The above emergency operations are subject to modification by the ERP. In case of discrepancies between the above-described operations and the ERP, the ERP will take precedent.

5.4 Pond A-2 Management

Pond A-2 will receive water from direct runoff, routine diversions of North Walnut Creek for wetland enhancement, and transfers from Pond A-1. Pond A-2 is generally maintained as a secondary storage pond for the North Walnut Creek drainage. Operations information for Pond A-2 is provided in Table 5−3.

Table 5−3. Pond A-2 Operations Information

	Elevation (feet)	Volume (MG)	% Full	Ops Mode
Maximum (drop structure elevation)	5,816.9	5.99	100	Emergency
Action Level 5[a]	>5,815.9	5.17	86	Emergency
Action Level 3/4[a]	5,814.9	4.43	74	Elevated Awareness
Preferred Max. Elevation	5,812.7	3.02	50	Normal
Normal Transfer Elevation	<5,811.5	<2.38	<40	Normal
Minimum Elevation	5,806.7	0.61	10	Normal
Primary Pond Management Sequence: A-2 to A-3 to A-4 to North Walnut Creek (discharge)				

[a]For reference only. Action levels are determined by pond and piezometer elevations, as well as dam conditions.
MG = million gallons

5.4.1 Normal Operations

The preferred operation at Pond A-2 is to transfer water to Pond A-3 for eventual discharge.

A functional outlet is not available at A-2. Water transfers from the pond must be accomplished with portable pumping equipment. Water can be pumped to the A-2 service spillway, subsequently flowing to Pond A-3.

Transfer will normally be initiated at any time the pond approaches 40 percent of volume. No sampling is required prior to transfer operations.

Notification of Pond A-2 operations will include the following guidelines:

- Operations personnel will provide, at a minimum, DOE, CDPHE, the Cities of Broomfield and Westminster, and EPA with the Rocky Flats pond status approximately monthly (Section 2.5.1). Pond levels and dam observations shall be field-collected once per month at a minimum and more frequently where conditions or action levels warrant.
- Pre-notification to DOE and others of transfer between interior ponds is not generally required. At a minimum, transfers will be noted on the Pond Status sheet.

5.4.2 Emergency Operations

Pond A-2 will be transferred to Pond A-3, regardless of water quality constraints listed above, under the following conditions:

1. The water elevation is 1 foot from the spillway elevation (Action Level 4), and further precipitation or inflow is predicted, or
2. The water elevation is less than 1 foot from the spillway elevation and uncontrolled overflow is imminent, or
3. An emergency condition requiring immediate discharge exists, per the ERP.

The above emergency operations are subject to modification by the ERP. In case of discrepancies between the above-described operations and the ERP, the ERP will take precedent.

5.5 Pond A-3 Management

Pond A-3 will receive normal base flow and stormwater runoff from the North Walnut Creek drainage, and occasional transfers from Ponds A-1 and A-2. Pond A-3 will discharge through its outlet works to Pond A-4. Operations information for Pond A-3 is provided in Table 5−4.

Table 5−4. Pond A-3 Operations Information

	Elevation (feet)	Volume (MG)	% Full	Ops Mode
Maximum (spillway elevation)	5,793.0	12.36	100	Emergency
Action Level 5[a]	>5,792.0	>10.91	88	Emergency
Action Level 3/4[a]	5,791.0	9.56	77	Elevated Awareness
Preferred Max. Elevation	5,788.1	6.08	50	Normal
Normal Discharge Elevation	<5,786.8	<4.92	<40	Normal
Minimum Elevation	5,781.4	1.24	10	Normal
Pond Management Sequence: A-3 to A-4 to North Walnut Creek (discharge)				

[a]For reference only. Action levels are determined by pond and piezometer elevations, as well as dam conditions.
MG = million gallons

5.5.1 Normal Operations

The method of operation for Pond A-3 is to discharge through the outlet works directly to Pond A-4.

Discharge will normally be initiated at any time the pond exceeds 40 percent of volume, although normal discharges will occur at less than 40 percent of volume. No sampling is required prior to discharge operations.

Pond A-3 discharge rates and quantity shall be measured at gaging station GS12 during the discharge.

Notification of Pond A-3 operations will include the following guidelines:

- Operations personnel will provide, at a minimum, DOE, CDPHE, the Cities of Broomfield and Westminster, and EPA with the Rocky Flats pond status approximately monthly (Section 2.5.1). Pond and piezometer levels and dam observations shall be field-collected once per month at a minimum and more frequently where conditions or action levels warrant.
- Pre-notification to DOE and others of discharge to A-3 is not generally required. At a minimum, transfers will be noted on the Pond Status sheet.

5.5.2 Emergency Operations

Pond A-3 will be transferred to Pond A-4, regardless of water quality constraints listed above, under the following conditions:

1. The water elevation is 1 foot from the spillway elevation (Action Level 4), and further precipitation or inflow is predicted, or
2. The water elevation is less than 1 foot from the spillway elevation and uncontrolled overflow is imminent, or
3. An emergency condition requiring immediate discharge exists, per the ERP, or
4. Overtopping of Pond A-2 is imminent.

The above emergency operations are subject to modification by the ERP. In case of discrepancies between the above-described operations and the ERP, the ERP will take precedent.

5.6 Pond A-4 Management

Pond A-4 will receive routine discharges from Pond A-3 and nonroutine transfers from Pond B-5. Pond A-4 will discharge directly to North Walnut Creek below Dam A-4. Operations information for Pond A-4 is provided in Table 5−5.

Table 5−5. Pond A-4 Operations Information

	Elevation (feet)	Volume (MG)	% Full	Ops Mode
Maximum (spillway elevation)	5,757.9	32.14	100	Emergency
Action Level 5[a]	>5,756.9	29.38	91	Emergency
Action Level 3/4[a]	5,755.9	26.75	83	Elevated Awareness
Preferred Max. Elevation	5,751.1	15.86	50	Normal
Normal Sample Elevation	<5,749.3	<12.87	<40	Normal
Minimum Elevation	5,741.2	3.26	10	Normal
Pond Management Sequence: A-4 to North Walnut Creek (discharge)				

[a]For reference only. Action levels are determined by pond and piezometer elevations, as well as dam conditions.
MG = million gallons

5.6.1 Normal Operations

The method of operation for Pond A-4 is to discharge it directly into North Walnut Creek without treatment upon receipt and dissemination of acceptable pre-discharge sample results.

Discharge activities may be terminated after a 0.5-inch storm event. The pond may need to be resampled for the required analytes if the potential for contaminant inflow exists.[1] Otherwise, the discharge can be reinitiated 24 hours after the end of the storm event.

Pre-discharge sampling will normally be initiated at any time the pond exceeds 40 percent of capacity, although normal pre-discharge sampling will occur at less than 40 percent of volume. Pre-discharge sampling will not be conducted until transfers from Ponds A-3 and B-5 have ceased.

Analysis for Pond A-4 water quality will include the following guidelines (see RFLMA and the RFSOG):

- Pond A-4 shall be sampled prior to discharge. Samples shall be split with CDPHE.
- Pond A-4 samples shall be analyzed by the Site and CDPHE for analytes listed for pre-discharge sampling in RFLMA.
- If the water meets stream standards for Walnut Creek, the water may be discharged without treatment. If the water does not meet standards, the water should be reanalyzed for the analyte of concern and an attempt made to identify the source of the exceedance. Additionally, DOE will consult with CDPHE.

Notification of Pond A-4 operations will include the following guidelines:

- Operations personnel will provide, at a minimum, DOE, CDPHE, the Cities of Broomfield and Westminster, and EPA with the Rocky Flats pond status approximately monthly (Section 2.5.1). Pond and piezometer levels and dam observations shall be field-collected once per month at a minimum and more frequently where conditions or action levels warrant.

[1] In most cases, Pond A-4 will be isolated from inflows by Pond A-3.

- Operations personnel will provide, at a minimum, DOE, CDPHE, the Cities of Broomfield and Westminster, EPA, and other interested parties with copies of water quality analytical data 24 hours prior to discharging for normal discharges (Section 2.5.2). Emergency discharges may be immediately initiated upon dissemination of results, or without results, as warranted by the ERP.
- Operations personnel will obtain approval to discharge from DOE.

5.6.2 Emergency Operations

Pond A-4 will be discharged, with or without treatment, to North Walnut Creek, if water quality analysis is incomplete or exceeds standards, under the following conditions:

1. The water elevation is 1 foot from the spillway elevation (Action Level 4), and further precipitation or inflow is predicted, or
2. The water elevation is less than 1 foot from the spillway elevation and uncontrolled overflow is imminent, or
3. An emergency condition requiring immediate discharge exists, per the ERP.

The above emergency operations are subject to modification by the ERP. In case of discrepancies between the above-described operations and the ERP, the ERP will take precedent.

5.7 Pond B-1 Management

Pond B-1 will receive water from direct runoff and routine diversions of South Walnut Creek for wetland enhancement. Pond B-1 is generally maintained and used as a secondary storage pond for the South Walnut Creek drainage and as wetlands habitat. Operations information for Pond B-1 is provided in Table 5−6.

Table 5−6. Pond B-1 Operations Information

	Elevation (feet)	Volume (MG)	% Full	Ops Mode
Maximum (spillway elevation)	5,882.0	0.86	100	Emergency
Action Level 5[a]	>5,881.0	0.60	70	Emergency
Action Level 3/4[a]	5,880.0	0.38	45	Elevated Awareness
Preferred Max. Elevation	5,880.0	0.38	45	Normal
Normal Transfer Elevation	Per Wetlands Requirements			Normal
Minimum Elevation	Per Wetlands Requirements			Normal
Pond Management Sequence: B-1 to B-2 to B-3 to B-4 to B-5 to South Walnut Creek (discharge)				

[a]For reference only. Action levels are determined by pond and piezometer elevations, as well as dam conditions.
MG = million gallons

5.7.1 Normal Operations

The method of operation for Pond B-1 is to transfer water to the South Walnut Creek Bypass Pipeline. Normal operation of B-1 is as a wetlands habitat.

A functional outlet is not available at Pond B-1. Water transfers from the pond must be accomplished with portable pumping equipment. Water can be pumped to the manhole in the South Walnut Creek Bypass Pipeline, subsequently flowing to Pond B-4.

Pond B-1 will maintain a minimum pool elevation as directed by the Site Ecology Lead for wetlands habitat. Pump intake lines will be situated so as to minimize the disturbance of pond sediments.

Transfer may be initiated when the pond exceeds required levels for wetlands habitat. No sampling is required prior to transfer operations.

Notification of Pond B-1 operations will include the following guidelines:

- Operations personnel will provide, at a minimum, DOE, CDPHE, the Cities of Broomfield and Westminster, and EPA with the Rocky Flats pond status approximately monthly (Section 2.5.1). Pond and piezometer levels and dam observations shall be field-collected once per month at a minimum and more frequently where conditions or action levels warrant.
- Pre-notification to DOE and others of transfer between interior ponds is not generally required. At a minimum, transfers will be noted on the Pond Status sheet.

5.7.2 Emergency Operations

Pond B-1 will be transferred to Pond B-2, regardless of water quality constraints listed above, under the following conditions:

1. The water elevation is 1 foot from the spillway elevation (Action Level 4), and further precipitation or inflow is predicted, or
2. The water elevation is less than 1 foot from the spillway elevation and uncontrolled overflow is imminent, or
3. An emergency condition requiring immediate discharge exists, per the ERP.

The above emergency operations are subject to modification by the ERP. In case of discrepancies between the above-described operations and the ERP, the ERP will take precedent.

5.8 Pond B-2 Management

Pond B-2 will receive water from direct runoff and routine transfers of Pond B-1. Pond B-2 is generally maintained and used as a secondary storage pond for the South Walnut Creek drainage and as wetlands habitat. Operations information for Pond B-2 is provided in Table 5−7.

Table 5−7. Pond B-2 Operations Information

	Elevation (feet)	Volume (MG)	% Full	Ops Mode
Maximum (drop structure elevation)	5,868.9	1.48	100	Emergency
Action Level 5[a]	>5,867.9	1.13	79	Emergency
Action Level 3/4[a]	5,866.9	0.81	55	Elevated Awareness
Preferred Operational Range, Max.	5,866.7	0.75	50	Normal
Normal Transfer Elevation	Per Wetlands Requirements			Normal
Minimum Elevation	Per Wetlands Requirements			Normal
Pond Management Sequence: B-2 to B-3 to B-4 to B-5 to South Walnut Creek (discharge)				

[a]For reference only. Action levels are determined by pond and piezometer elevations, as well as dam conditions.
MG = million gallons

5.8.1 Normal Operations

The method of operation for Pond B-2 is to transfer water to Pond B-3 for eventual discharge. Normal operation of Pond B-2 is as a wetlands habitat.

A functional outlet is not available at B-2. Water transfers from the pond must be accomplished with portable pumping equipment.

Pond B-2 will maintain a minimum pool elevation as directed by the Site Ecology Lead for wetlands habitat. Pump intake lines will be situated so as to minimize the disturbance of pond sediments.

Transfer may be initiated when the pond exceeds required levels for wetlands habitat. No sampling is required prior to transfer operations.

Notification of Pond B-2 operations will include the following guidelines:

- Operations personnel will provide, at a minimum, DOE, CDPHE, the Cities of Broomfield and Westminster, and EPA with the Rocky Flats pond status approximately monthly (Section 2.5.1). Pond levels and dam observations shall be field-collected once per month at a minimum and more frequently where conditions or action levels warrant.
- Pre-notification to DOE and others of transfer between interior ponds is not generally required. At a minimum, transfers will be noted on the Pond Status sheet.

5.8.2 Emergency Operations

Pond B-2 will be transferred to Pond B-3, regardless of water quality constraints listed above, under the following conditions:

1. The water elevation is 1 foot from the spillway elevation (Action Level 4), and further precipitation or inflow is predicted, or
2. The water elevation is less than 1 foot from the spillway elevation and uncontrolled overflow is imminent, or
3. An emergency condition requiring immediate discharge exists, per the ERP.

The above emergency operations are subject to modification by the ERP. In case of discrepancies between the above-described operations and the ERP, the ERP will take precedent.

5.9 Pond B-3 Management

Pond B-3 will receive water from direct runoff and routine transfers of Pond B-2. Pond B-3 is generally maintained in a flow-through configuration and can be used as a secondary storage pond for the South Walnut Creek drainage, but is primarily used as wetlands habitat. Operations information for Pond B-3 is provided in Table 5−8.

Table 5−8. Pond B-3 Operations Information

	Elevation (feet)	Volume (MG)	% Full	Ops Mode
Maximum (spillway elevation)	5,853.0	0.95	100	Emergency
Action Level 5[a]	>5,852.0	0.74	77	Emergency
Action Level 3/4[a]	5,851.0	0.56	56	Elevated Awareness
Preferred Max. Elevation	5,850.6	0.48	50	Normal
Normal Elevation (flow-through; riser elevation)	5,849.2	0.28	31	Normal
Minimum Elevation	Per Wetlands Requirements			Normal
Pond Management Sequence: B-3 to B-4 to B-5 to South Walnut Creek (discharge)				

[a]For reference only. Action levels are determined by pond and piezometer elevations, as well as dam conditions.
MG = million gallons

5.9.1 Normal Operations

The method of operation for Pond B-3 is to maintain an open outlet works with direct discharge to B-4 for flow-through discharge to B-5. Normal operation of B-3 is as a wetlands habitat.

A functional outlet with an overflow elevation (riser elevation) of 5,849.2 is available at Pond B-3.

Pond B-3 will maintain a minimum pool elevation as directed by the Site Ecology Lead for wetlands habitat.

Pond B-3 is typically operated as a flow-through structure with the outlet valve left open and water automatically flowing through the overflow. No sampling is required prior to discharge.

Notification of Pond B-3 operations will include the following guidelines:

- Operations personnel will provide, at a minimum, DOE, CDPHE, the Cities of Broomfield and Westminster, and EPA with the Rocky Flats pond status approximately monthly (Section 2.5.1). The B-3 pond level is generally not monitored because of the flow-through nature of the pond. Piezometer levels and dam observations shall be field-collected once per month at a minimum and more frequently where conditions or action levels warrant.
- Pre-notification to DOE and others of transfer between interior ponds is not generally required. At a minimum, transfers will be noted on the Pond Status sheet.

5.9.2 Emergency Operations

Pond B-3 will be discharged to Pond B-4, regardless of water quality constraints listed above, under the following conditions:

1. The water elevation is 1 foot from the spillway elevation (Action Level 4), and further precipitation or inflow is predicted, or
2. The water elevation is less than 1 foot from the spillway elevation and uncontrolled overflow is imminent, or
3. An emergency condition requiring immediate discharge exists, per the ERP.

The above emergency operations are subject to modification by the ERP. In case of discrepancies between the above-described operations and the ERP, the ERP will take precedent.

5.10 Pond B-4 Management

Pond B-4 will receive discharges from Pond B-3, and stormwater runoff through the B-1 bypass pipeline. No active management of Pond B-4 will occur. Pond B-4 has no appreciable usable storage volume, is maintained at 100 percent volume at all times, and discharges over its spillway directly to Pond B-5.

5.11 Pond B-5 Management

Pond B-5 will be maintained as the primary stormwater detention pond for the South Walnut Creek drainage. Pond B-5 will receive normal stormwater runoff from the South Walnut Creek drainage basin. Pond B-5 will typically be discharged directly to South Walnut Creek through its outlet works, pursuant to meeting applicable water quality criteria. Operations information for Pond B-5 is provided in Table 5−9.

Table 5−9. Pond B-5 Operations Information

	Elevation (feet)	Volume (MG)	% Full	Ops Mode
Maximum (spillway elevation)	5,803.9	23.12	100	Emergency
Action Level 5[a]	>5,802.9	21.35	93	Emergency
Action Level 3/4[a]	5,801.9	19.67	85	Elevated Awareness
Preferred Max. Elevation	5,796.3	11.59	50	Normal
Normal Sample Elevation	<5,794.3	<9.29	<40	Normal
Minimum Elevation	5,784.8	2.33	10	Normal
Primary Pond Management Sequence: B-5 to South Walnut Creek (discharge) Secondary Pond Management Sequence: B-5 to A-4 to North Walnut Creek (transfer)				

[a]For reference only. Action levels are determined by pond and piezometer elevations, as well as dam conditions.
MG = million gallons

5.11.1 Normal Operations

The preferred operational mode for Pond B-5 is to discharge it directly to South Walnut Creek without treatment upon receipt and dissemination of acceptable pre-discharge sample results.

Discharge activities may be terminated after a 0.5-inch storm event. The pond may need to be resampled for the required analytes if the potential for contaminant inflow exists. Otherwise, the discharge can be reinitiated 24 hours after the end of the storm event.

Pre-discharge sampling will normally be initiated at any time the pond exceeds 40 percent of capacity, although normal pre-discharge sampling will occur at less than 40 percent of volume. Analysis for Pond B-5 water quality will include the following guidelines (see RFLMA and the RFSOG):

- Pond B-5 shall be sampled prior to discharge. Samples shall be split with CDPHE.
- Pond B-5 samples shall be analyzed by the Site and CDPHE for analytes listed for pre-discharge sampling in RFLMA.
- If the water meets stream standards for Walnut Creek, the water may be discharged without treatment. If the water does not meet standards, the water should be reanalyzed for the analyte of concern and an attempt made to identify the source of the exceedance. Additionally, DOE will consult with CDPHE.

Notification of Pond B-5 operations will include the following guidelines:

- Operations personnel will provide, at a minimum, DOE, CDPHE, the Cities of Broomfield and Westminster, and EPA with the Rocky Flats pond status approximately monthly (Section 2.5.1). Pond and piezometer levels and dam observations shall be field-collected once per month at a minimum and more frequently where conditions or action levels warrant.
- Operations personnel will provide, at a minimum, DOE, CDPHE, the Cities of Broomfield and Westminster, EPA, and other interested parties with copies of water quality analytical data 24 hours prior to discharging for normal discharges (Section 2.5.2). Emergency discharges may be immediately initiated upon dissemination of results, or without results, as warranted by the ERP.
- Operations personnel will obtain approval to discharge from DOE.

5.11.2 Emergency Operations

Emergency discharge of Pond B-5 to South Walnut Creek, or by pipeline to Pond A-4 or both, prior to receipt of analytical results, will occur if water quality analysis is incomplete or exceeds standards, under the following conditions:

1. The water elevation is 1 foot from the spillway elevation (Action Level 4), and further precipitation or inflow is predicted, or
2. The water elevation is less than 1 foot from the spillway elevation and uncontrolled overflow is imminent, or
3. An emergency condition requiring immediate discharge exists, per the ERP.

The above emergency operations are subject to modification by the ERP. In case of discrepancies between the above-described operations and the ERP, the ERP will take precedent.

5.12 Pond C-1 Management

Pond C-1 will receive flows from Woman Creek. No active management of Pond C-1 will occur. Pond C-1 has no appreciable usable storage volume, is maintained at 100 percent volume at all times, and discharges over its stop log structure directly into Woman Creek.

5.13 Pond C-2 Management

Pond C-2 will be maintained as the primary stormwater detention pond for runoff originating from the southern portion of the COU. Pond C-2 will receive stormwater runoff through the SID. Operations information for Pond C-2 is provided in Table 5−10.

Table 5−10. Pond C-2 Operations Information

	Elevation (feet)	Volume (MG)	% Full	Ops Mode
Maximum (spillway elevation)	5,765.3	22.69	100	Emergency
Action Level 5[a]	>5,764.3	19.97	88	Emergency
Action Level 3/4[a]	5,763.3	17.53	77	Elevated Awareness
Preferred Max. Elevation	5,760.3	11.29	50	Normal
Normal Sample Elevation	<5,759.0	<9.04	<40	Normal
Minimum Elevation	5,753.4	2.31	10	Normal
Pond Management Sequence: C-2 to Woman Creek (discharge)				

[a]For reference only. Action levels are determined by pond and piezometer elevations, as well as dam conditions.
MG = million gallons

5.13.1 Normal Operations

The method of operation for Pond C-2 is to discharge without treatment to Woman Creek upon receipt and dissemination of acceptable pre-discharge sample results.

Discharge activities may be terminated after a 0.5-inch storm event. The pond may need to be resampled for the required analytes if the potential for contaminant inflow exists. Otherwise, the discharge can be reinitiated 24 hours after the end of the storm event.

Pre-discharge sampling will normally be initiated at any time the pond exceeds 40 percent of capacity, although normal pre-discharge sampling will occur at less than 40 percent of volume. Analysis for Pond C-2 water quality will include the following guidelines (see RFLMA and the RFSOG):

- Pond C-2 shall be sampled prior to discharge. Samples shall be split with CDPHE.
- Pond C-2 samples shall be analyzed by the Site and CDPHE for analytes listed for pre-discharge sampling in RFLMA.
- If the water meets stream standards for Woman Creek, the water may be discharged without treatment. If the water does not meet standards, the water should be reanalyzed for

the analyte of concern and an attempt made to identify the source of the exceedance. Additionally, DOE will consult with CDPHE.

Notification of Pond C-2 operations will include the following guidelines:

- Operations personnel will provide, at a minimum, DOE, CDPHE, the Cities of Broomfield and Westminster, and EPA with the Rocky Flats pond status approximately monthly (Section 2.5.1). Pond and piezometer levels and dam observations shall be field-collected once per month at a minimum and more frequently where conditions or action levels warrant.
- Operations personnel will provide, at a minimum, DOE, CDPHE, the Cities of Broomfield and Westminster, EPA, and other interested parties with copies of water quality analytical data 24 hours prior to discharging for normal discharges (Section 2.5.2). Emergency discharges may be immediately initiated upon dissemination of results, or without results, as warranted by the ERP.
- Operations personnel will obtain approval to discharge from DOE.

5.13.2 Emergency Operations

Emergency discharge of Pond C-2 to Woman Creek, with or without treatment, prior to receipt of analytical results, will occur if water quality analysis is incomplete or exceeds standards, under the following conditions:

1. The water elevation is 1 foot from the spillway elevation (Action Level 4), and further precipitation or inflow is predicted, or
2. The water elevation is less than 1 foot from the spillway elevation and uncontrolled overflow is imminent, or
3. An emergency condition requiring immediate discharge exists, per the ERP.

The above emergency operations are subject to modification by the ERP. In case of discrepancies between the above-described operations and the ERP, the ERP will take precedent.

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6.0 References

City and County of Broomfield and DOE (U.S. Department of Energy), 2006. *Lease Agreement of September 26, 2006 Between Broomfield and DOE,* September.

DOE (U.S. Department of Energy), 2007. *Rocky Flats Legacy Management Agreement,* March 14.

DOE (U.S. Department of Energy), 2008a. *Emergency Response Plan for the Rocky Flats Site Dams*, September.

DOE (U.S. Department of Energy), 2008b. *Rocky Flats Site Operations Guide*, September.

Guo, James C.Y, 2004a. *Urban Flood Channel Design and Culvert Hydraulics,* Storm Water Hydrologist Certificate Course, The University of Colorado at Denver College of Engineering and Applied Science.

Guo, James C.Y, 2004b. *Trapezoidal Channel Design and Flow Analysis* (CHANNELDESIGN), The University of Colorado at Denver College of Engineering and Applied Science.

Simons, Li & Associates, 1982. *Surface Mining Water Diversion Design Manual,* Ft. Collins, Colorado.

State of Colorado Department of Water Resources, 2002. *Dam Safety Manual*, January.

State of Colorado Department of Water Resources, 2007. *Rules and Regulations for Dam Safety and Dam Construction*, January.

UDFCD (Urban Drainage and Flood Control District), 2001. *Urban Storm Drainage Criteria Manual, Volume I,* June.

Viessman, W. and G.L. Lewis, 2003. *Introduction to Hydrology,* 5th ed., Prentice Hall.

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